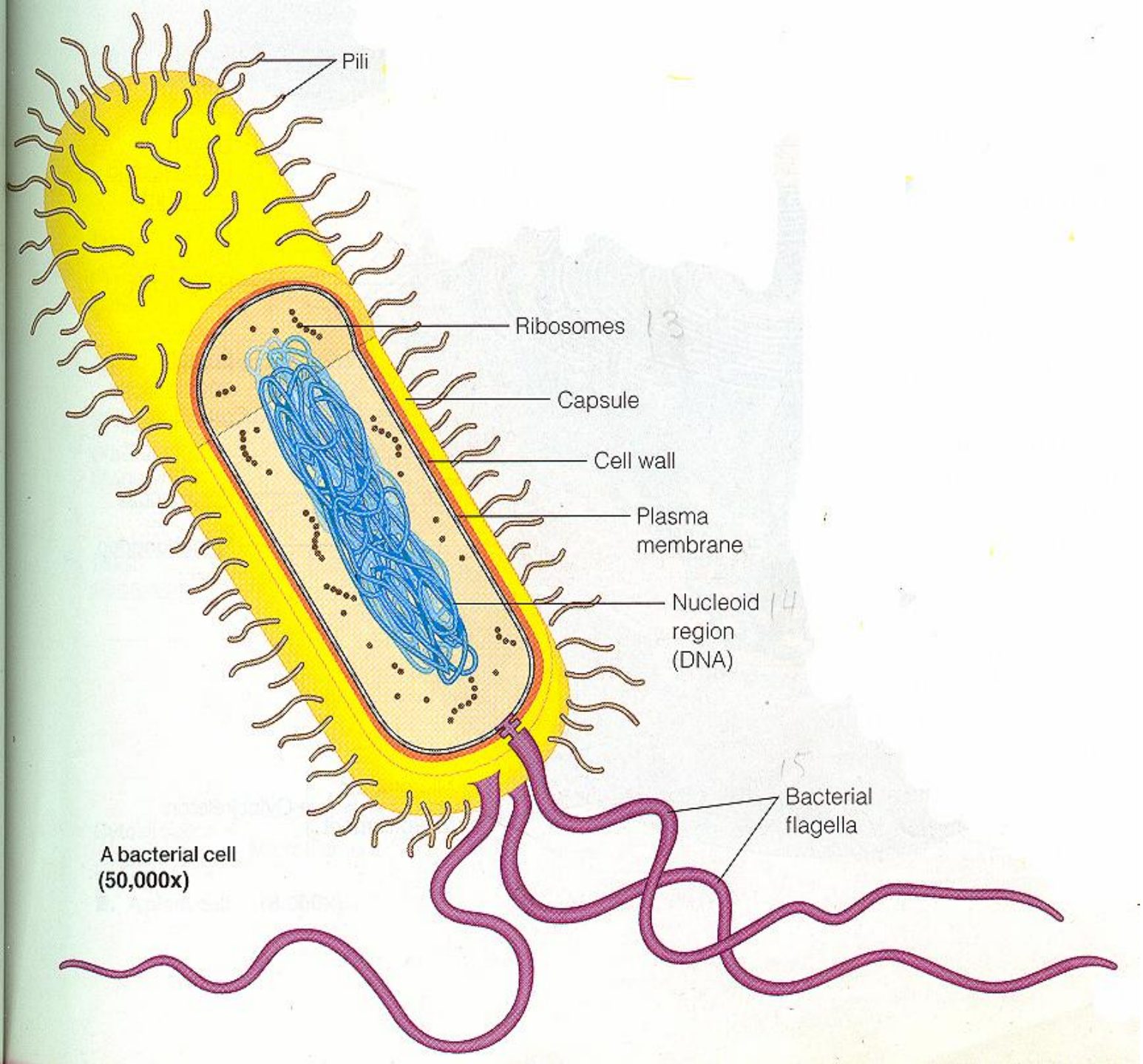
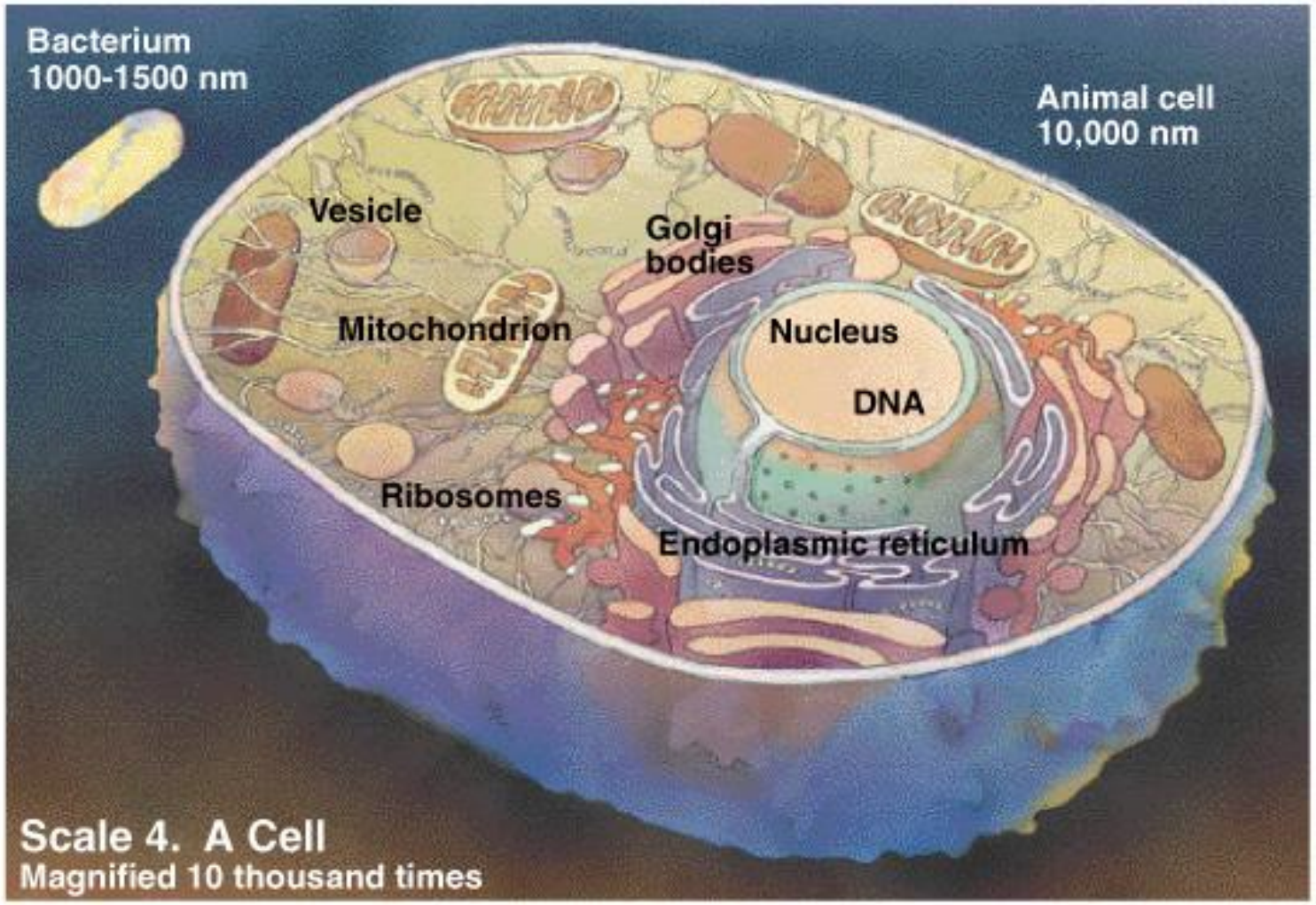
Two Basic Types of Cells

- Prokaryotic- bacteria
  - larger than eukaryotic cells
  - lacks a nucleus but has a nucleiod (a region of coiled DNA)
    - DNA is in direct contact with rest of cells contents
  - Cell wall- a rigid complex structure that protects the cell and helps to maintain its shape
  - Some have a sticky outer coat called a capsule that further protects the cell and helps to adhere the cell to surfaces
  - Some have projections
    - Pili- short projections that aid in adhesion
    - flagella- used to propel through the liquid environment
- Eukaryotic- all other forms of life

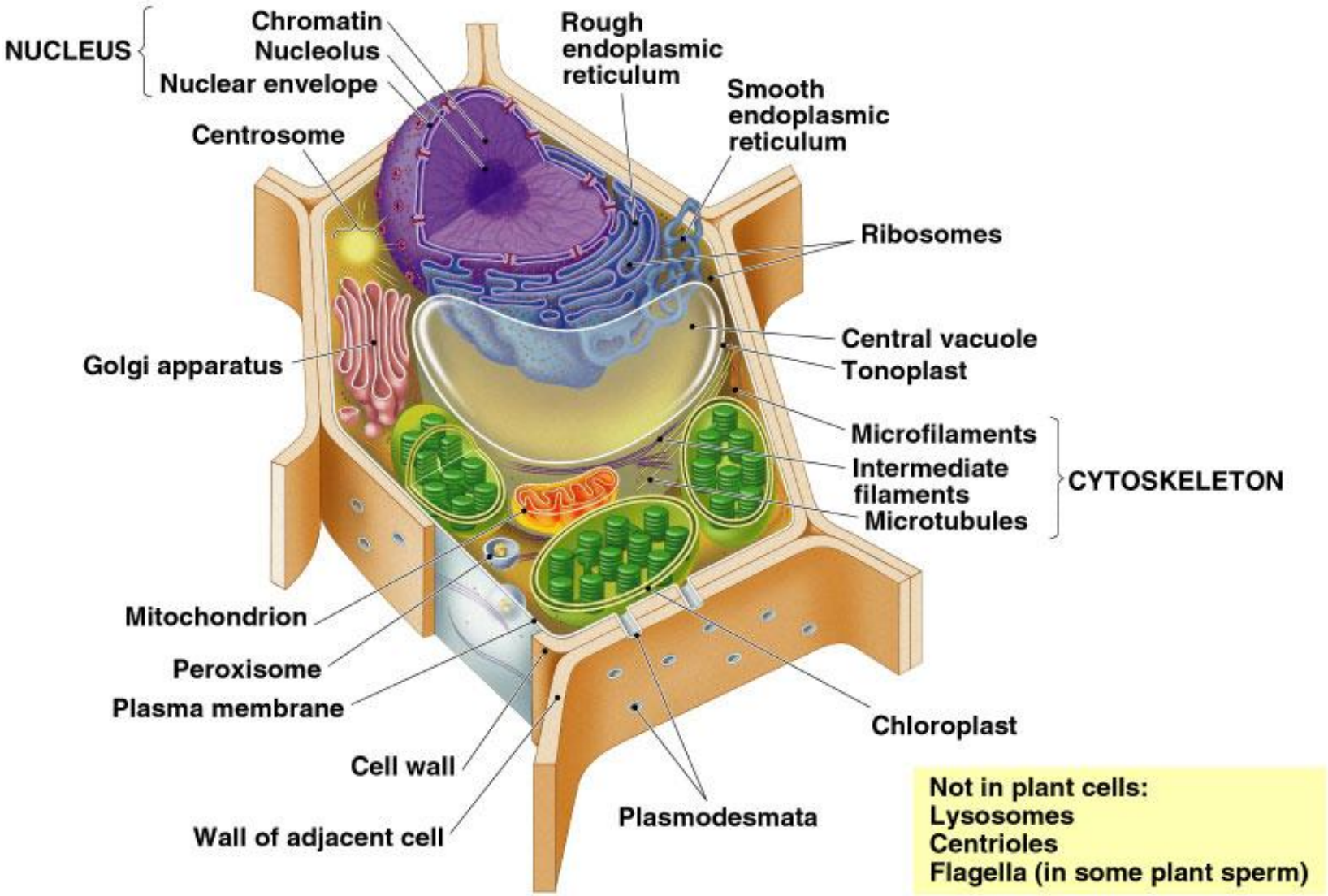

Pili
Ribosomes
Capsule
Cell wall
Plasma membrane
Nucleoid region (DNA)
Bacterial flagella
A bacterial cell (50,000x)

Bacteria

Human Cell

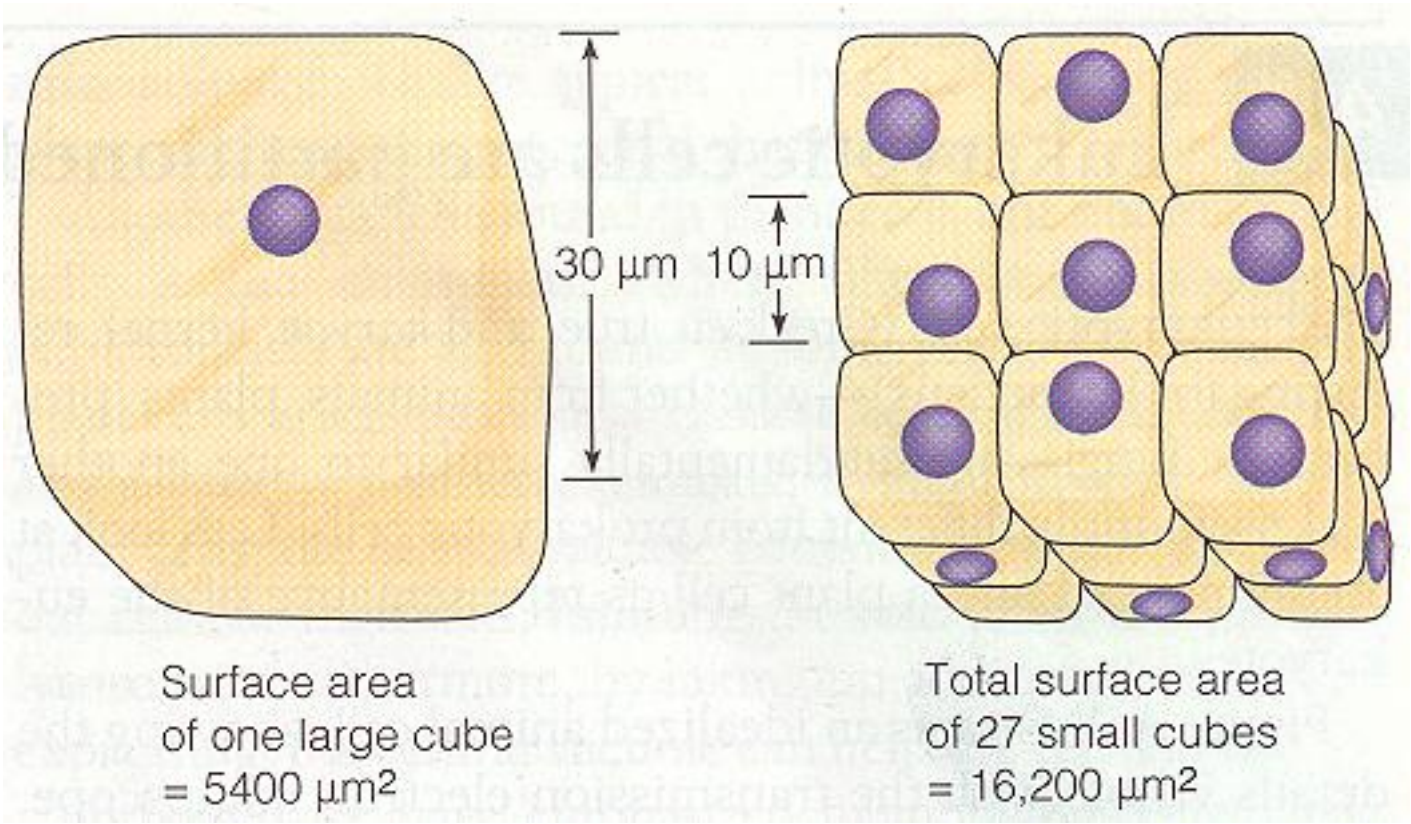

Bacterium
1000-1500 nm
Animal cell
10,000 nm
Vesicle
Golgi
bodies
Mitochondrion
Nucleus
DNA
Ribosomes
Endoplasmic reticulum
Scale 4. A Cell
Magnified 10 thousand times

Plant Cell



Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

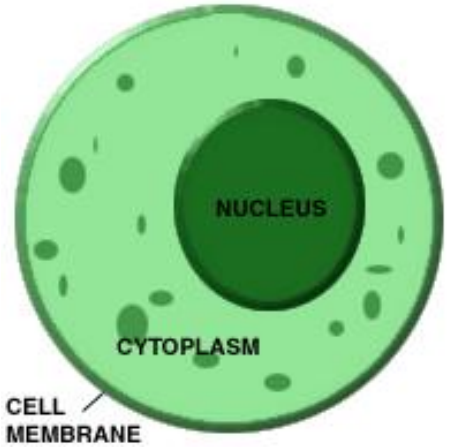
Natural Laws Limit Cell Size



Generalized Cell

Three parts

- Plasma (cell) membrane- the limiting membrane that separates the outer from the internal cell environment
- Cytoplasm- all the cellular contents between the plasma membrane and the nucleus
  - cytosol- the thick semifluid portion of the cytoplasm
- Organelles- the highly organized structures in the cytoplasm that are specialized for particular functions.

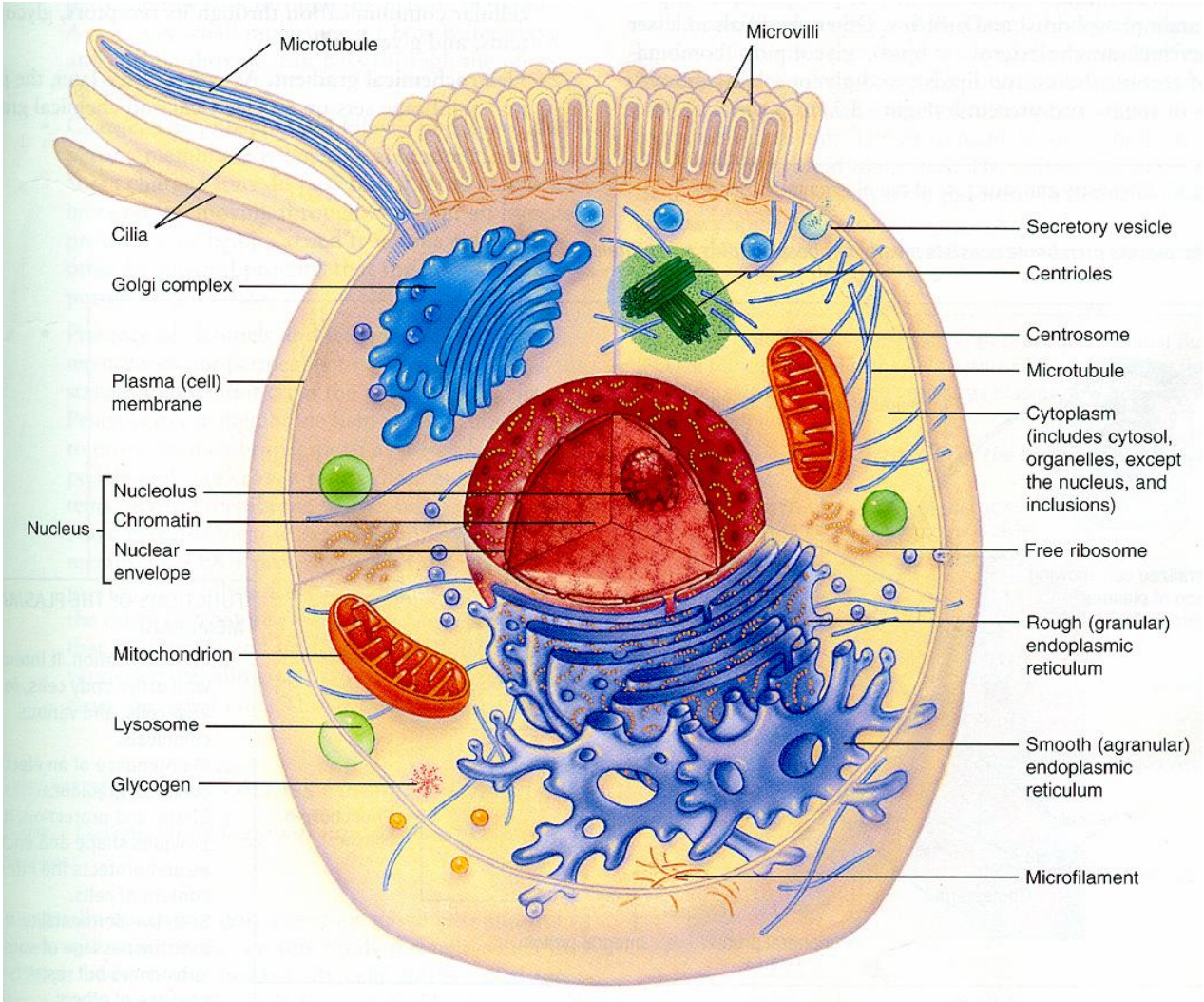


Organelles

- Membranous organelles- surrounded by one or two layers of unit membrane
  - Nucleus
  - Mitochondria
  - Lysosomes
  - Peroxisomes
  - Endoplasmic reticulum
  - Golgi complex
- Non membranous organelles- not membrane bound
  - Ribosome
  - Centrosome
  - Centrioles
  - Basal bodies

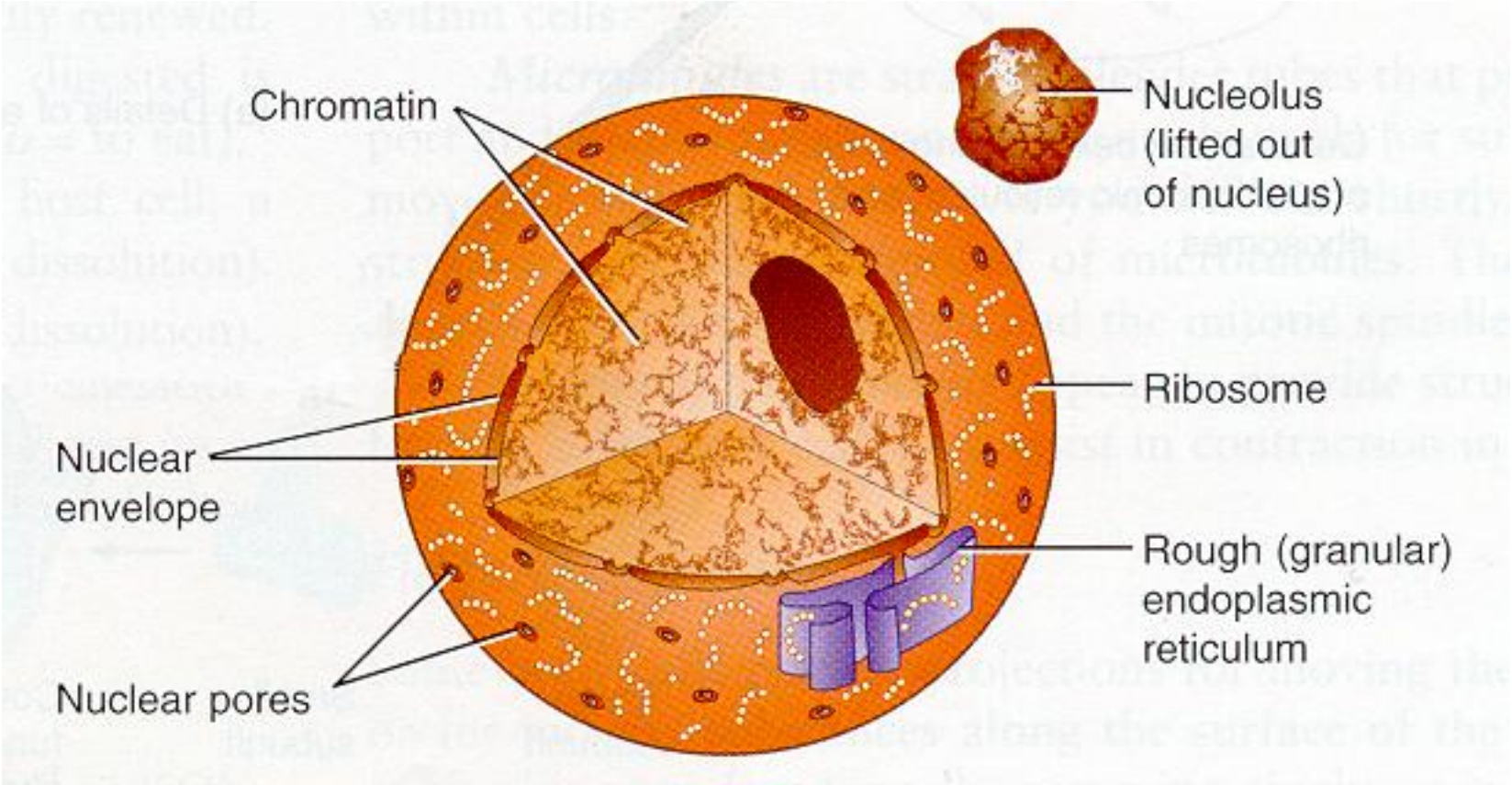
Organelles

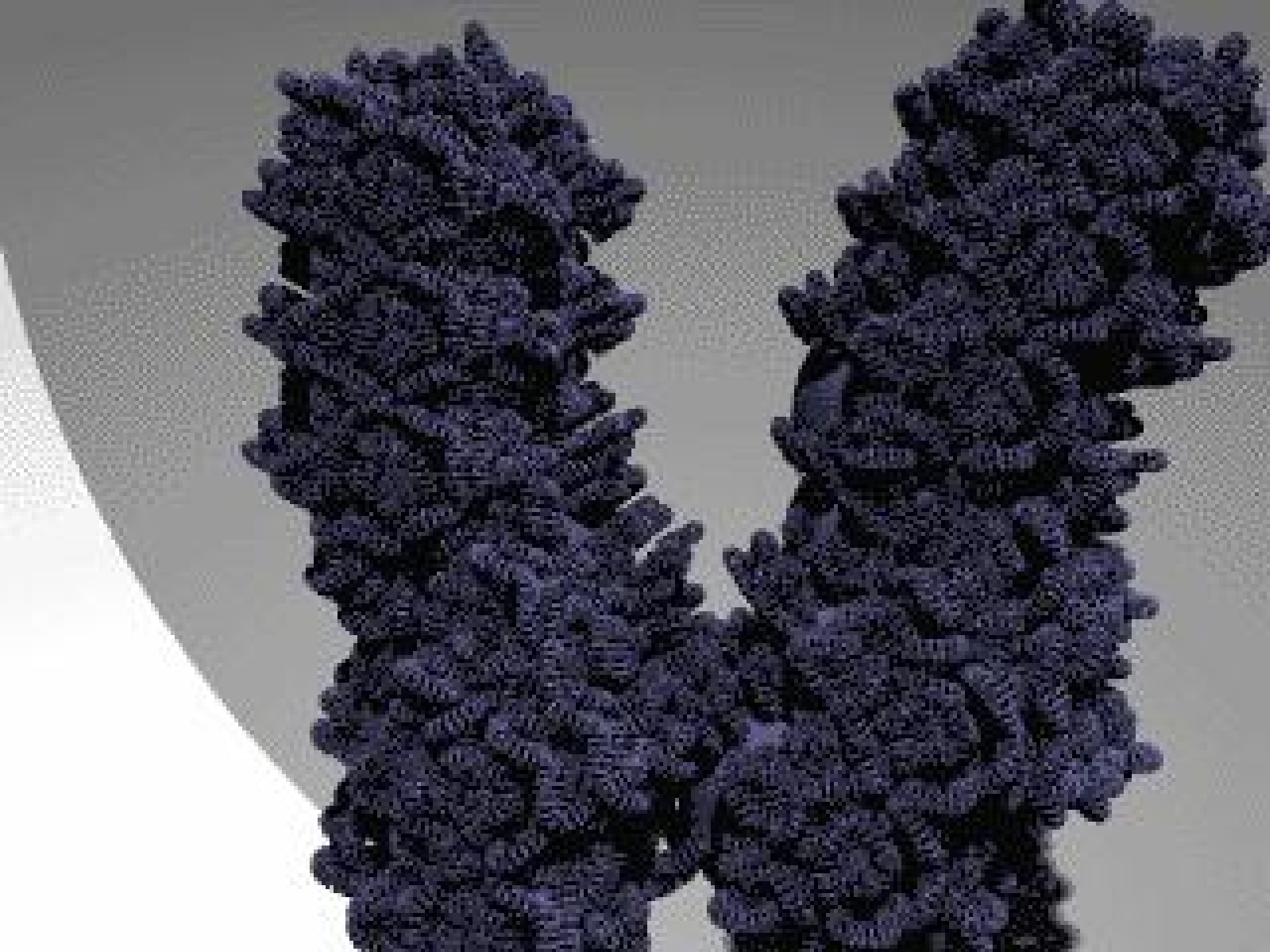
Provides separate chemical environments for the various specialized reactions of the cell



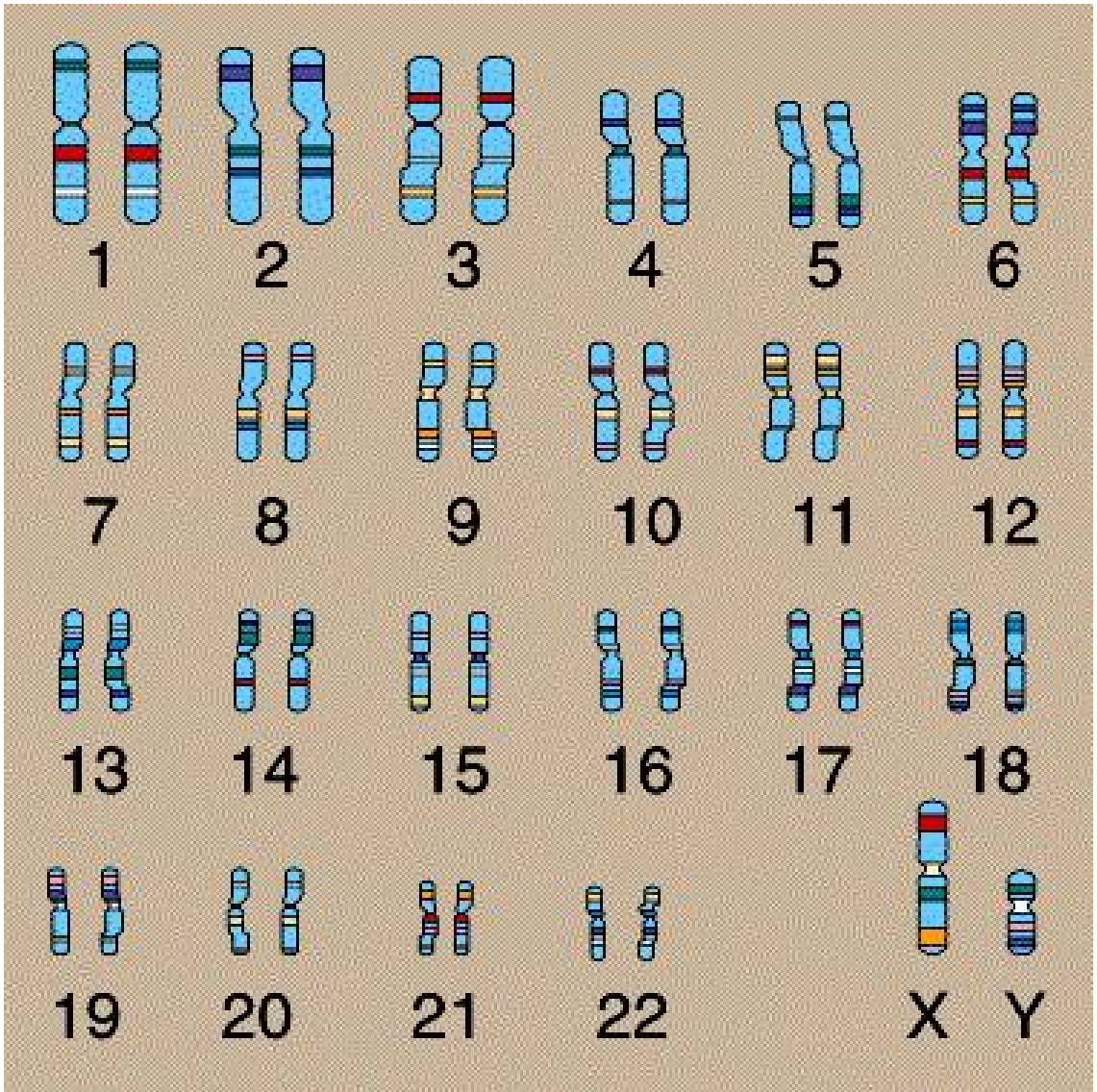
Nucleus

- largest structure in the cell
- called the control center because it contains the genetic material
  - chromatin- loosely dispersed DNA associated with protein
  - chromosomes- condensed DNA strands



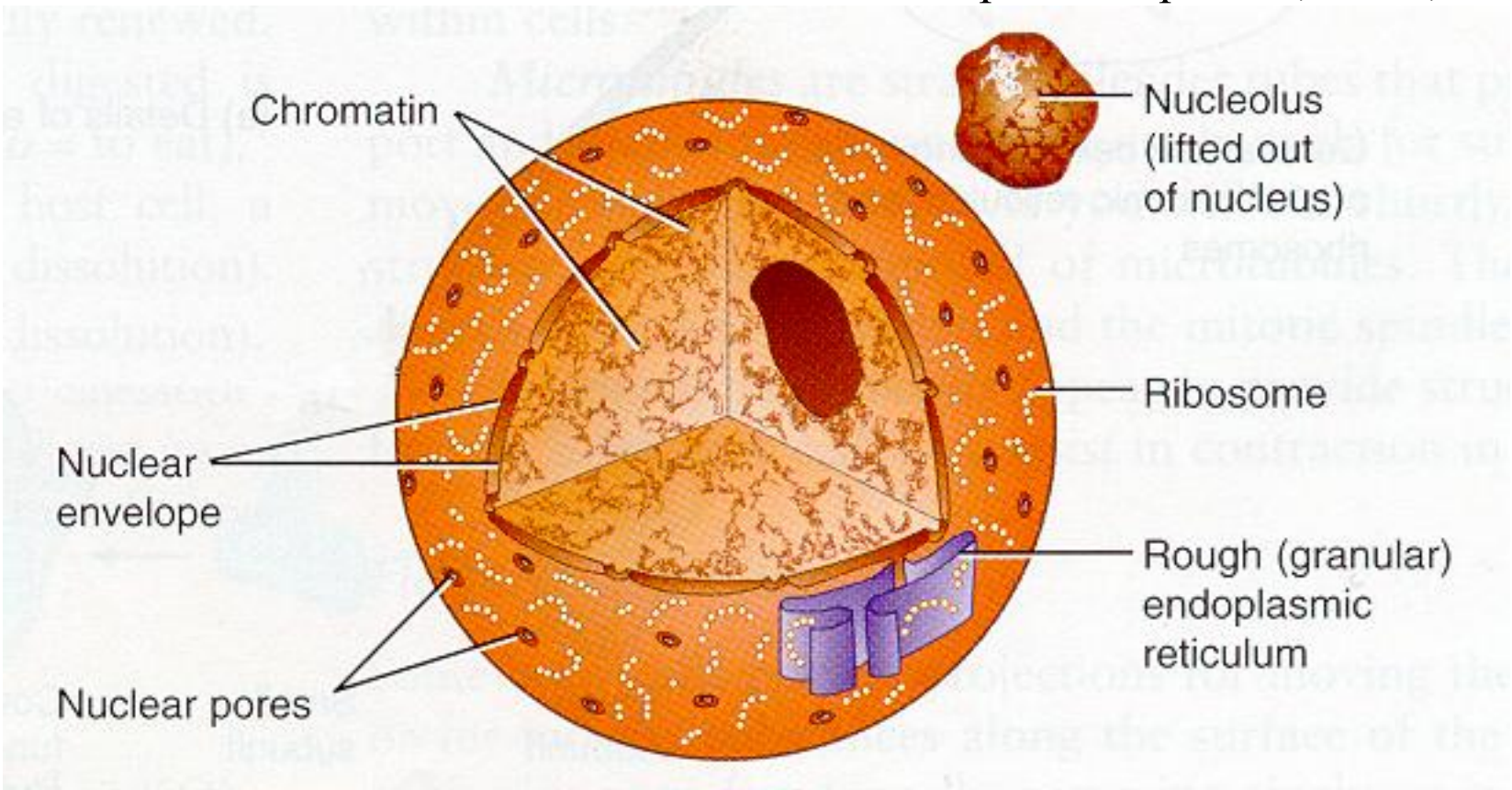


Karyotype



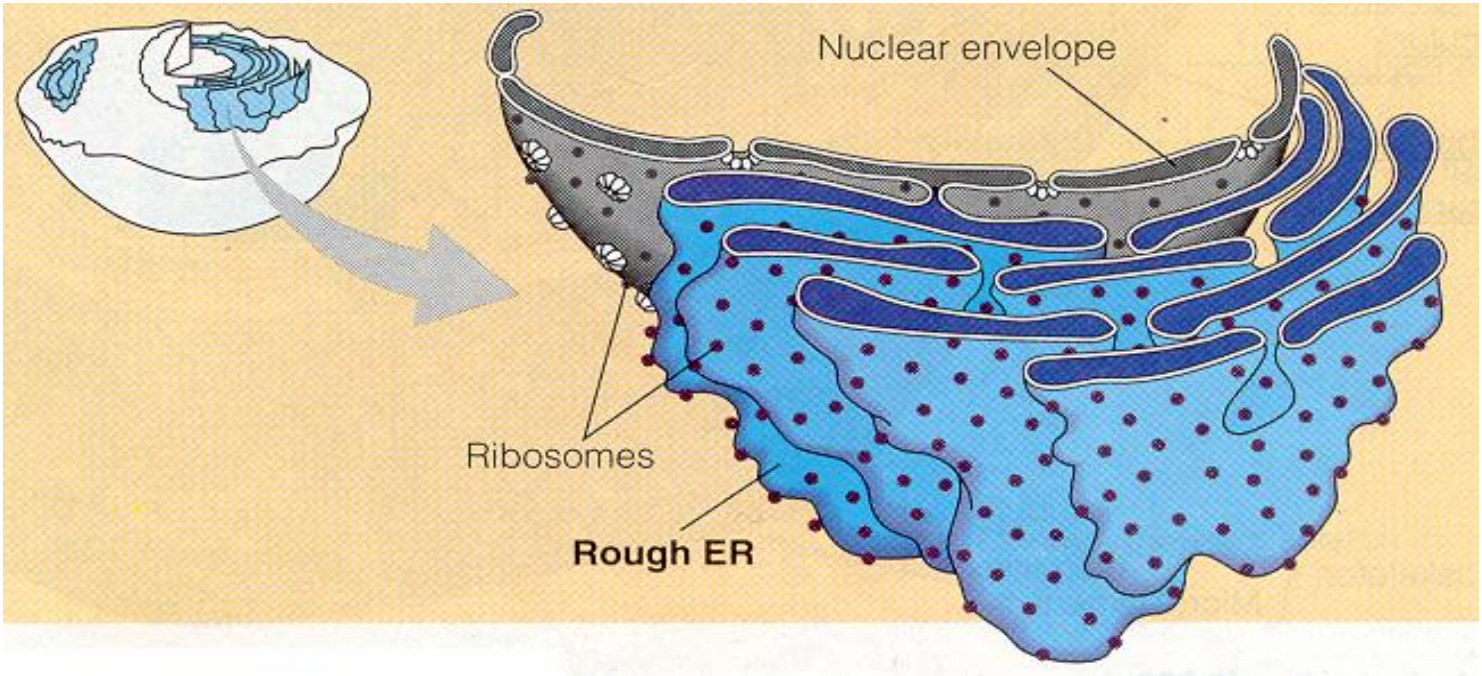
Nucleus (cont.)

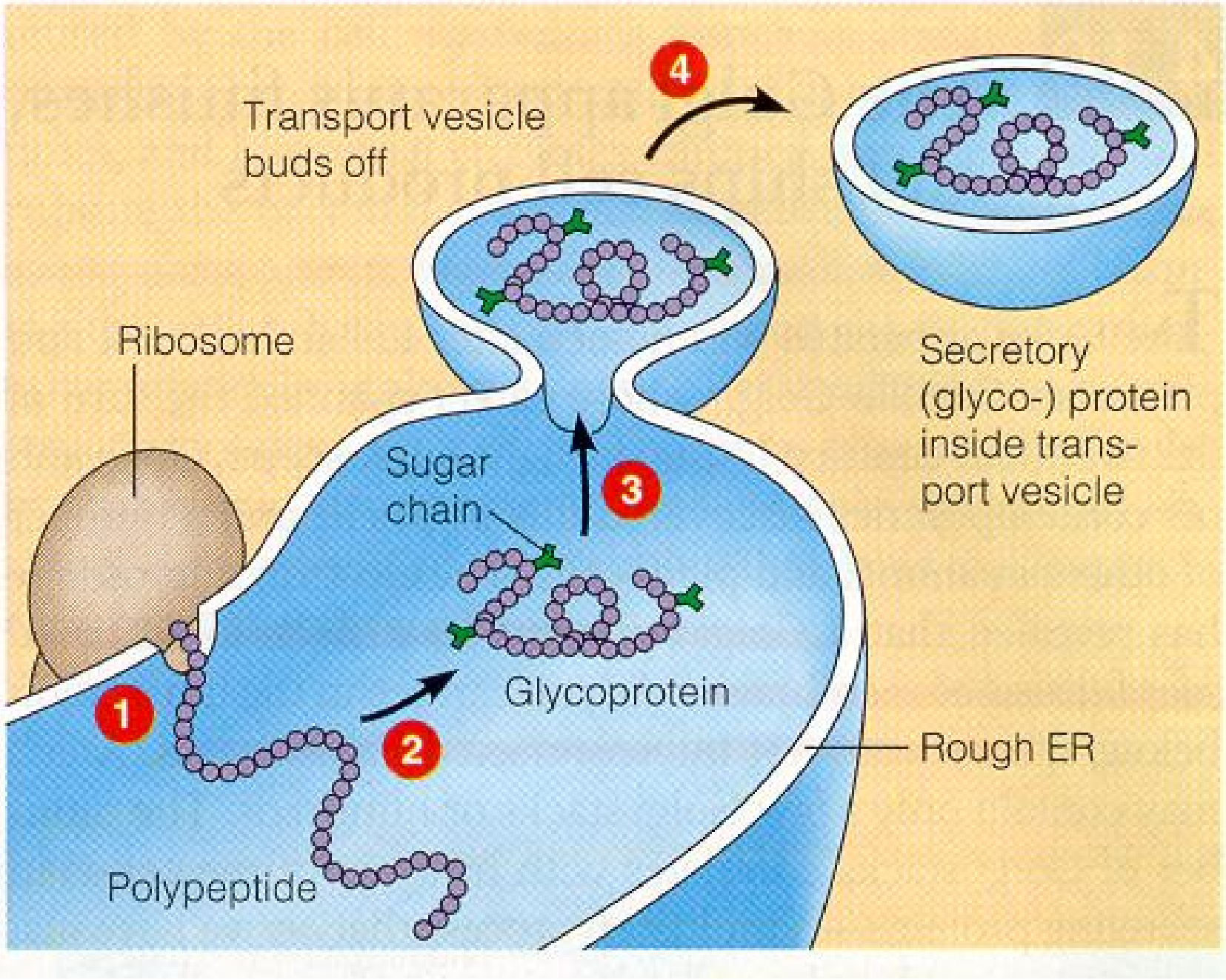
- nuclear contents bound by a membranous sac called a **nuclear envelope** (double layered membrane)
- studded with ribosomes- place of protein synthesis
- nuclear pores- provide communication with cytoplasm
- continuous with endoplasmic reticulum
- contains nucleolus- unenclosed area composed of protein, DNA,



Endoplasmic Reticulum

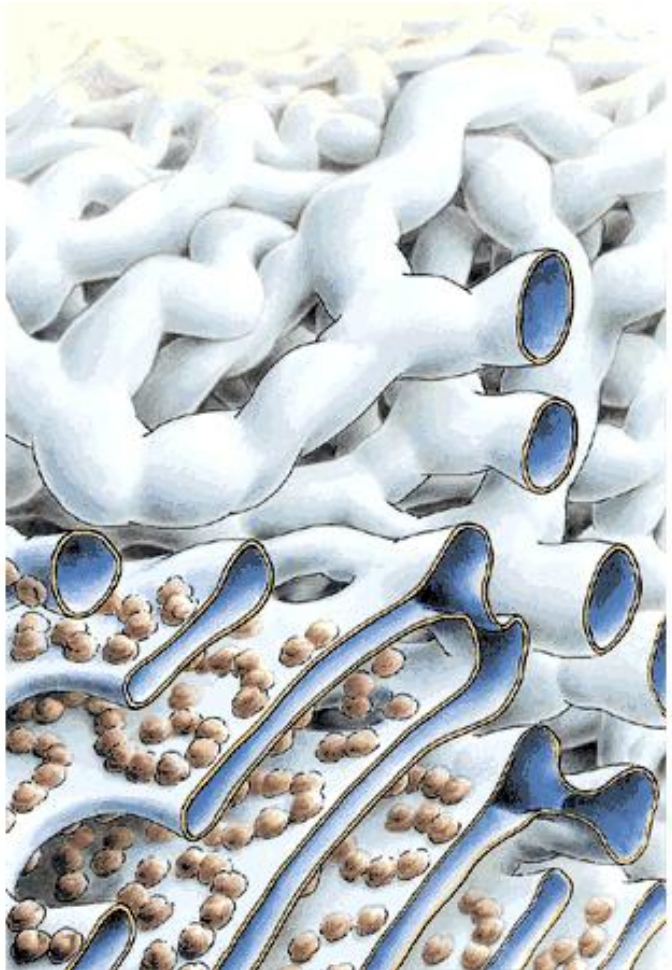
- a system of membranous flattened sacs (cisterns) dispersed throughout the cytoplasm
- Two types- Rough and smooth
  - Rough endoplasmic reticulum
    - studded with ribosomes on the outer surface
    - makes more membrane and processes secretory proteins manufactured by the ribosomes
    - membrane continuous with the nuclear envelope




Transport vesicle buds off
4
Ribosome
Sugar chain
3
Secretory (glyco-) protein inside transport vesicle
Glycoprotein
1
2
Rough ER
Polypeptide

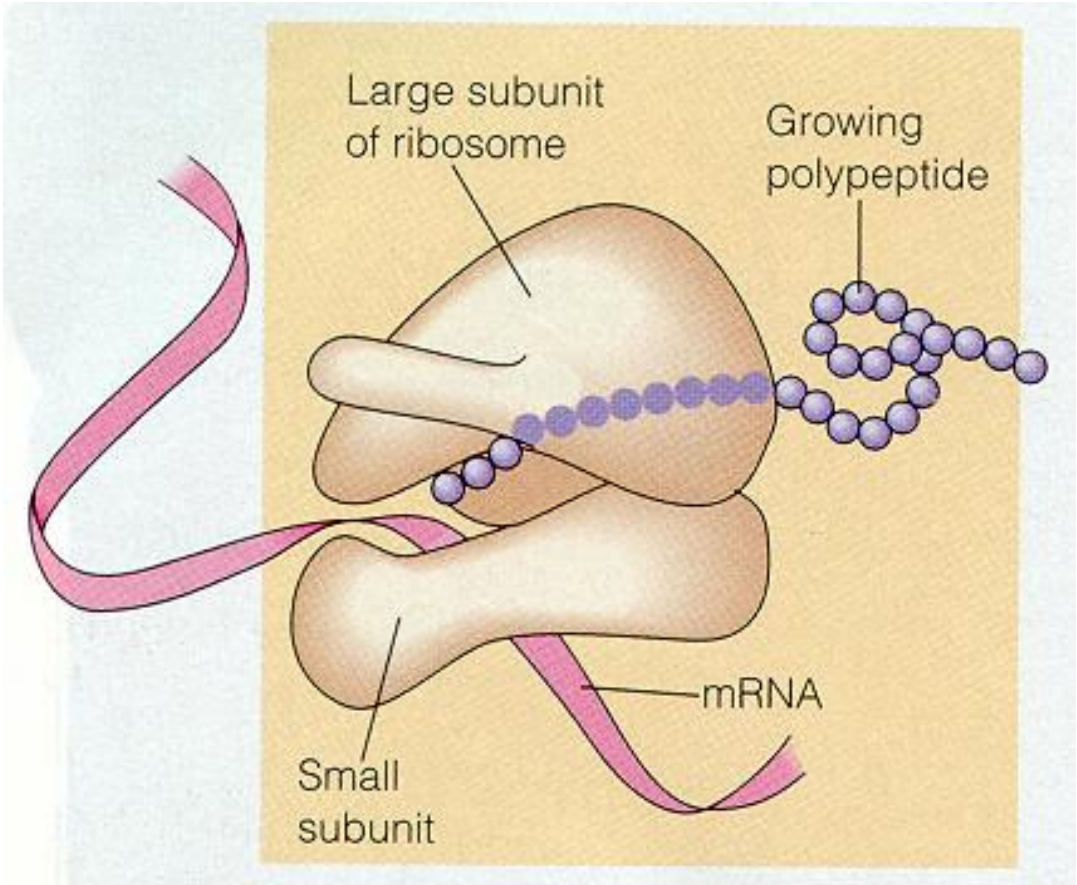
Endoplasmic Reticulum

- Smooth endoplasmic reticulum
  - network of interconnected tubes void of ribosomes
  - continuous with rough ER
  - site of fatty acid, phospholipid, and steroid synthesis
    - in certain cells the enzymes within the smooth ER inactivates or detoxifies various chemicals (i.e., alcohol, pesticides, carcinogens)



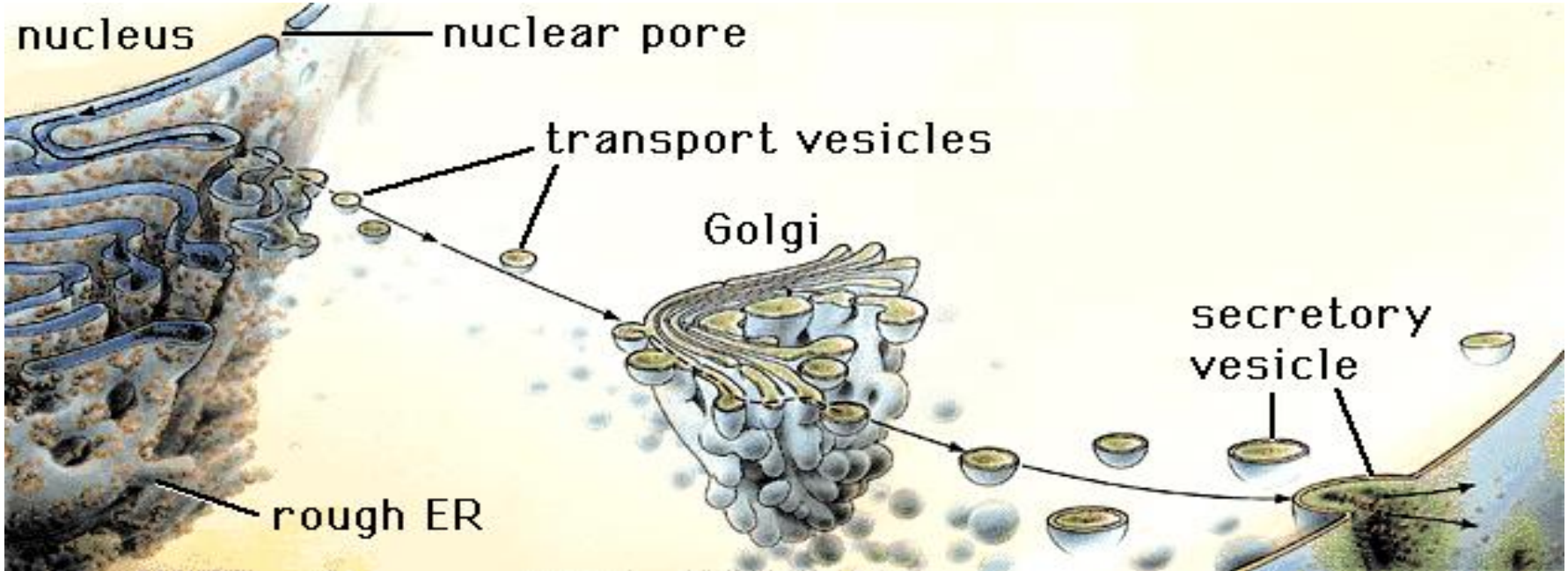
Ribosome

- Small granules composed of ribosomal RNA and protein
- sites of protein synthesis
- are scattered throughout the cytoplasm and attached to ER
- composed of 2 subunits



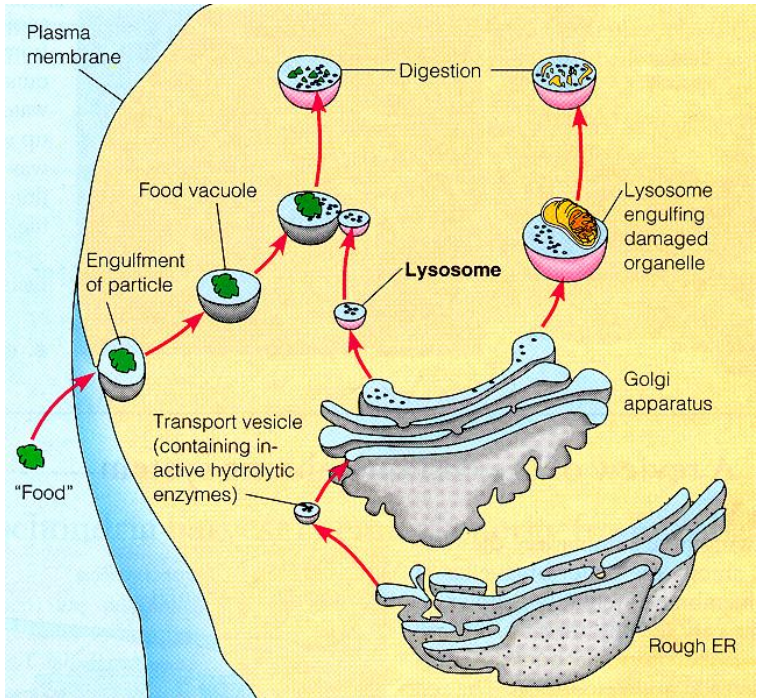
Golgi Complex

- a system of stacked flattened sacs (cisterns) with expanded areas at their ends
- has golgi vesicles that cluster along the expanded edges of the cisterns
- is the "shipping and receiving" dock for newly synthesized lipids and proteins
  - packages them into transport (secretory) vesicles that release the products to the external of the cell



Lysosomes

- membrane enclosed sacs formed the golgi complex that contains powerful digestive enzymes
- used to foreign substances and organisms
- digest old organelles (autophagy) for recycling
- capable of digesting the cell (autolysis)
- enzymes can also be used external to the cell in injury repair

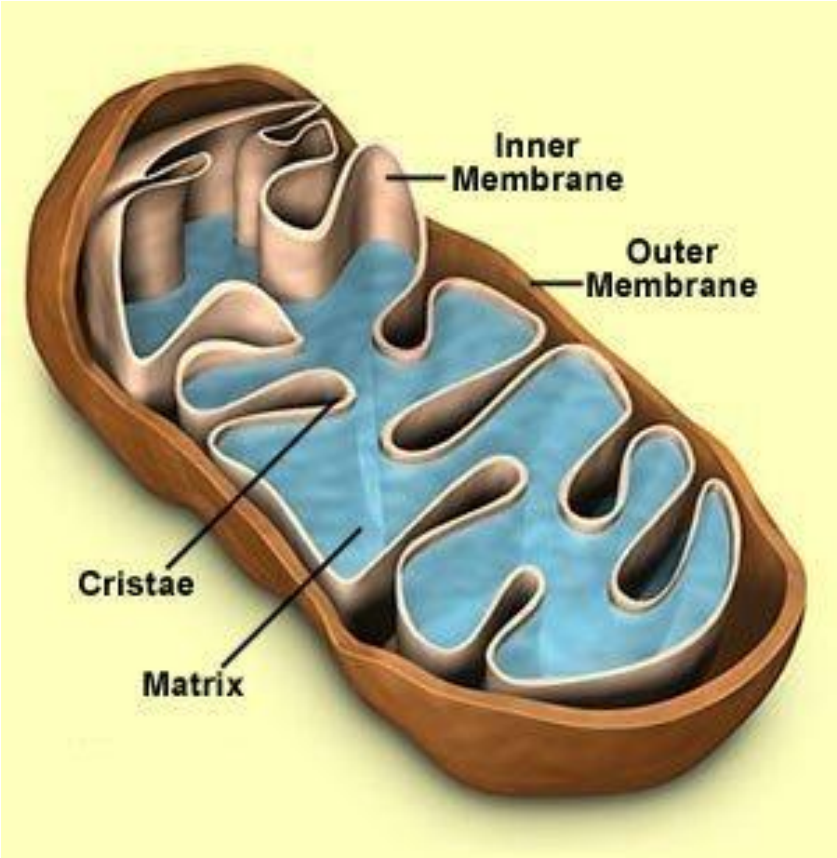


Peroxisomes

- Resemble lysosomes but contain different enzymes.
- The enzymes and other proteins destined for peroxisomes are synthesized in the cytosol.
- Buds from the endoplasmic reticulum, not the golgi.
- Peroxisomes , kill bacteria, neutralize free radicals, breaks down fatty acids, and detoxify alcohol and other drugs.
- In the course of detoxification and the distruction of microorgansims , they produce hydrogen peroxide (H_2O_2).
- Contain catalase, an enzyme that breaks down hydrogen peroxide which is dangerous to the cell.

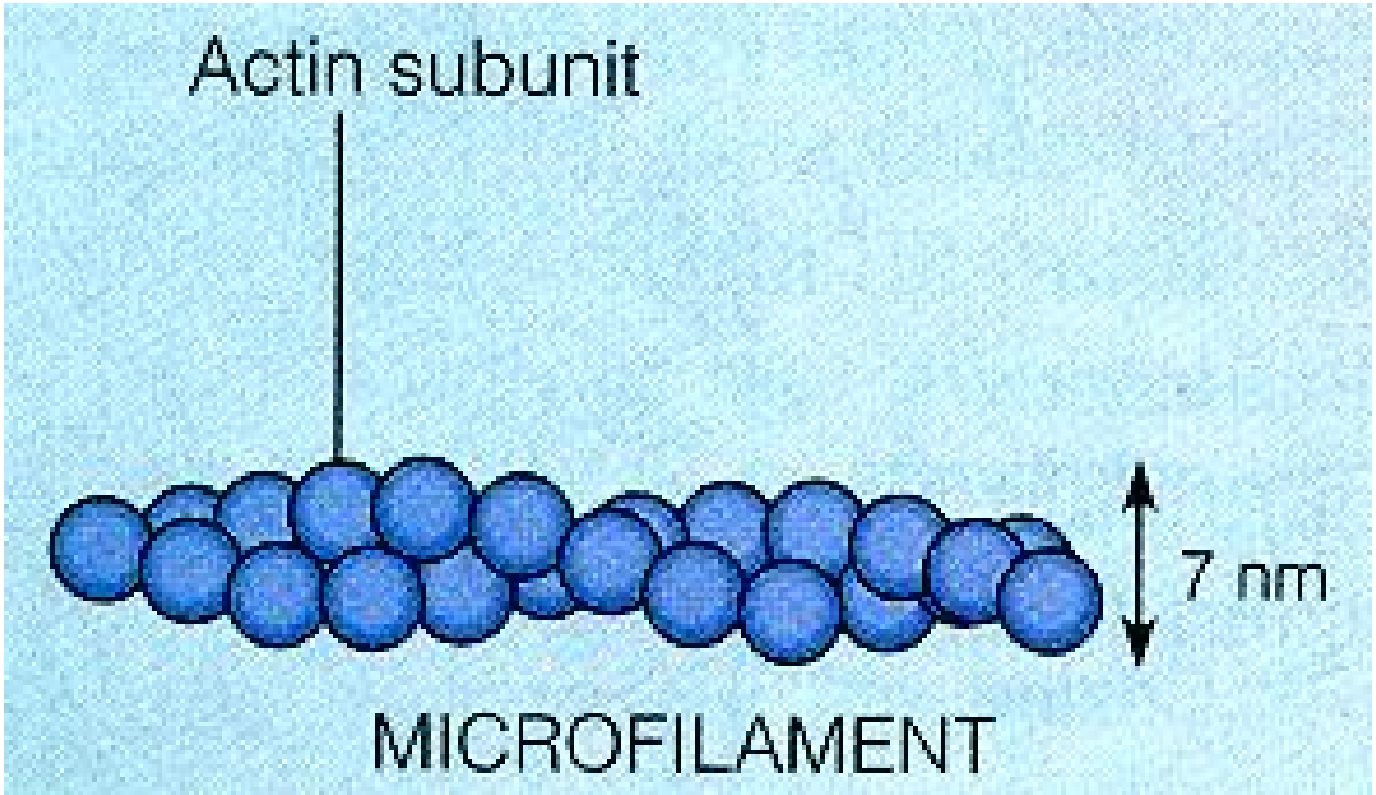
Mitochondria

- The powerhouse of the cell because of it function in energy production
- Consist of two membranes
  - outer membrane- smooth
  - inner membrane- arranged in folds (cristae) where ATP is generated
- Center core called matrix
- Found throughout the cytoplasm of all cells, especially in cells that expend a lot of energy (i.e. muscle, liver..etc.)



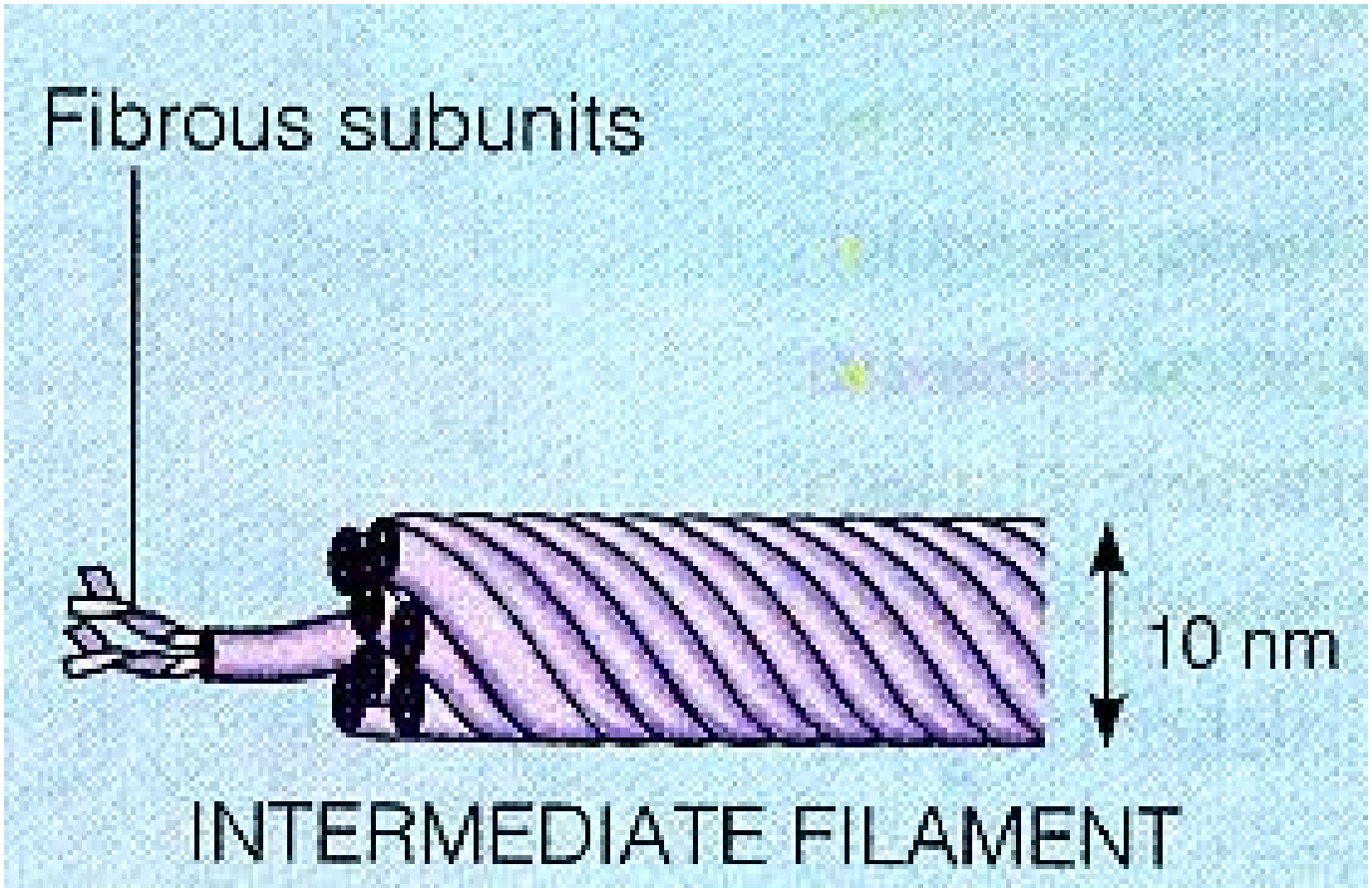
Cytoskeleton

- A supportive meshwork of fine fibers that provide structural support for the cell
- three main types of fibers
  - microfilaments - helical rodlike globular protein (actin) structures involved in contraction in muscle cells and provide support, shape, and assist in locomotion in nonmuscular cells



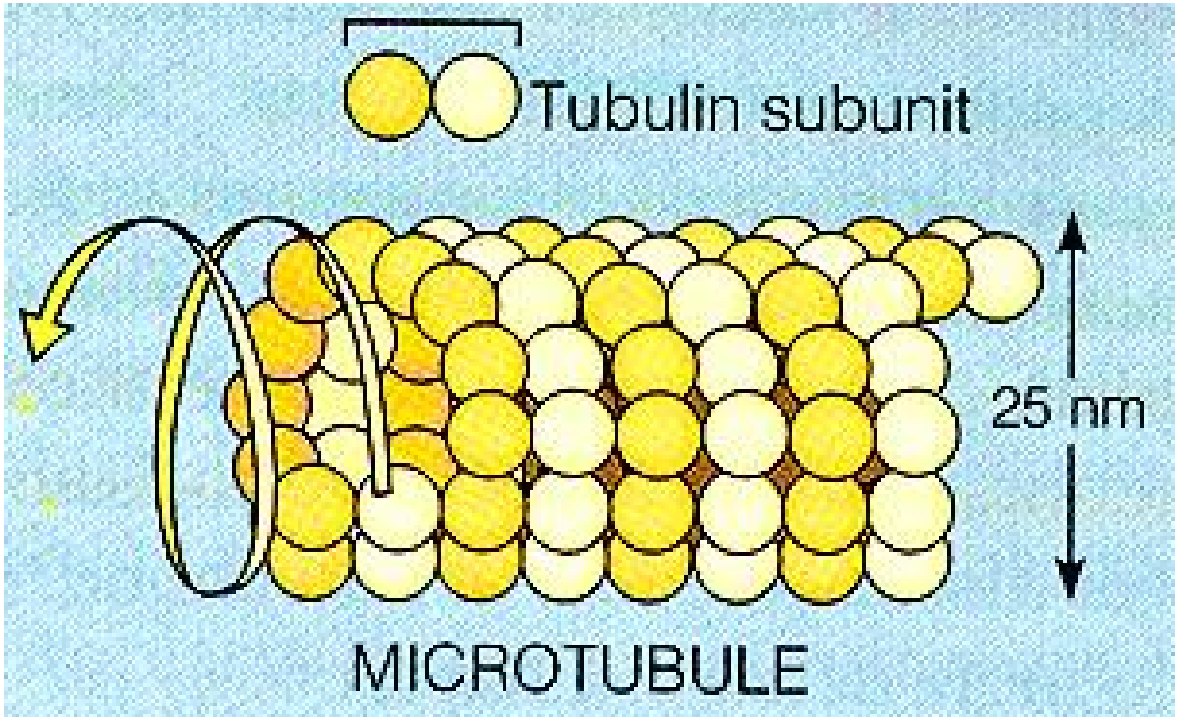
Cytoskeleton (cont.)

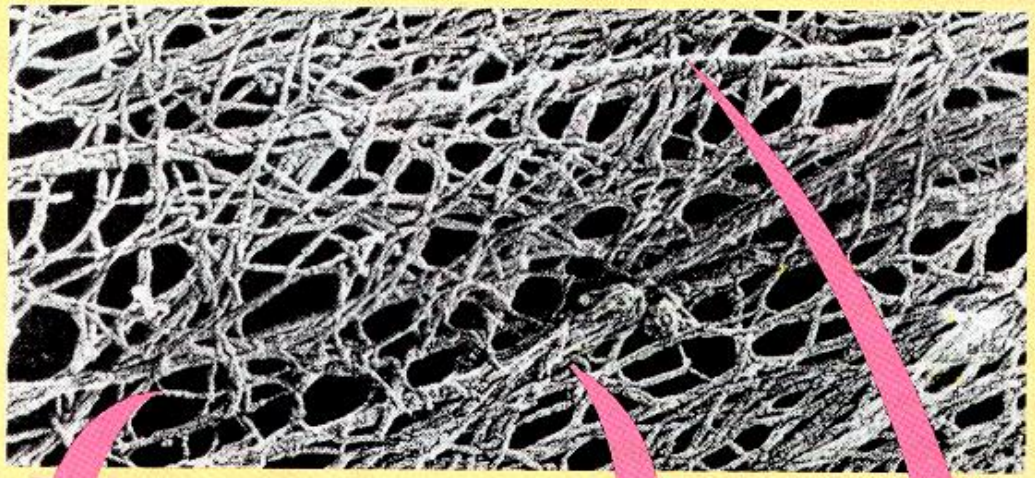
- intermediate filaments- fibrous ropelike protein structures that serve as reinforcing rods for bearing tension and for anchoring certain organelles

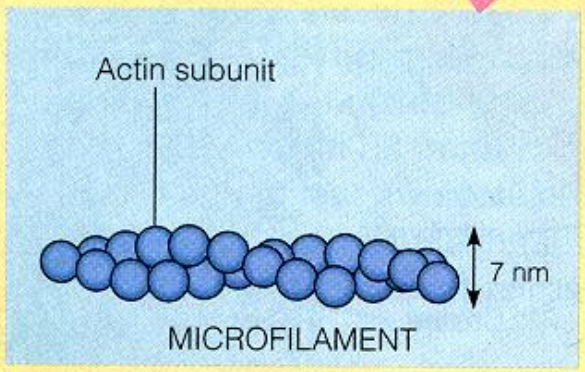


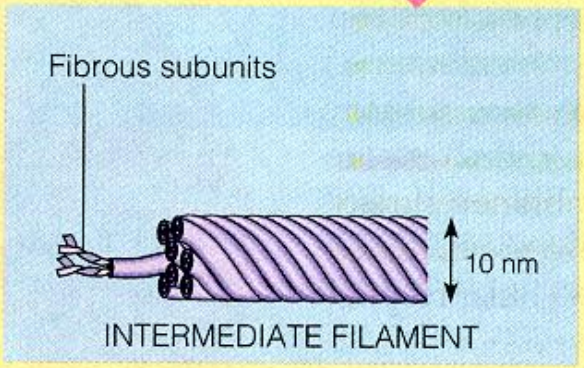
Microtubules

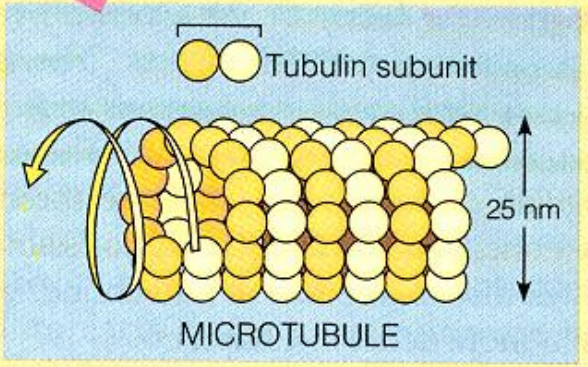
- straight hollow tubes composed of globular proteins called tubulins
- provide anchorage of organelles and act as tracks along which organelles can move within the cytoplasm
- guide the movement of chromosomes in cell division
- the structural basis for flagella and cilia




TEM 51,000


Actin subunit
7 nm
MICROFILAMENT


Fibrous subunits
10 nm
INTERMEDIATE FILAMENT


Tubulin subunit
25 nm
MICROTUBULE

Cilia and Flagella

Both consist of microtubules surrounded by cytosol and enclosed by plasma membrane

- Cilia- short numerous appendages used for locomotion and the movement of substances along the surface of the cell
- Flagella- longer, generally less numerous appendages used for locomotion (sperm)

Cilia and Flagella

- These motile appendages are constructed by basal bodies (kinetostomes), which also function as centrioles.
- The basal body is located at the base of each filament, anchoring it to the cell and controlling its movement.
- Cilia and flagella have the same structure. The only difference is that the flagella are longer.

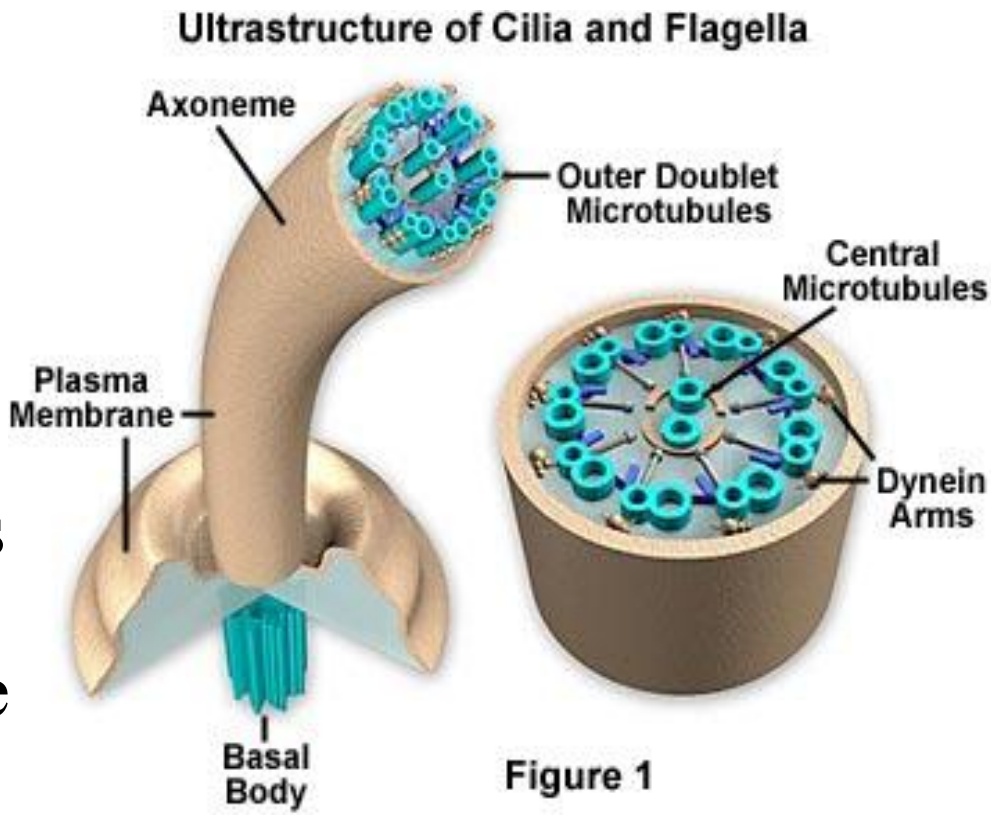
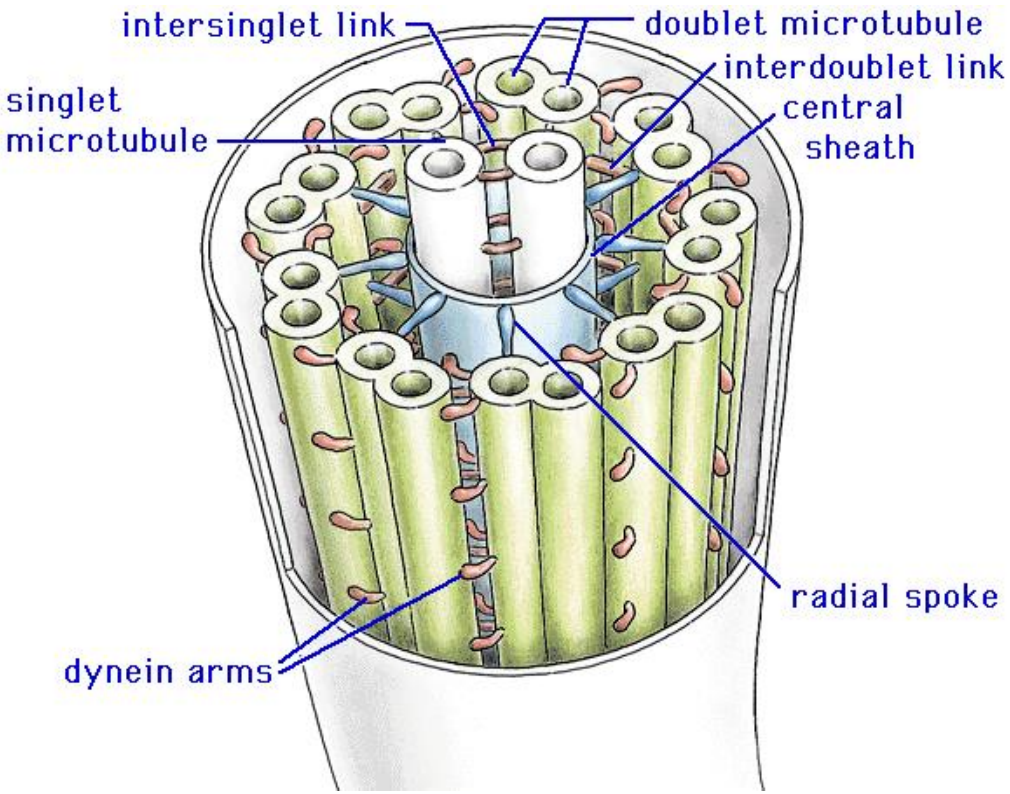


Figure 1

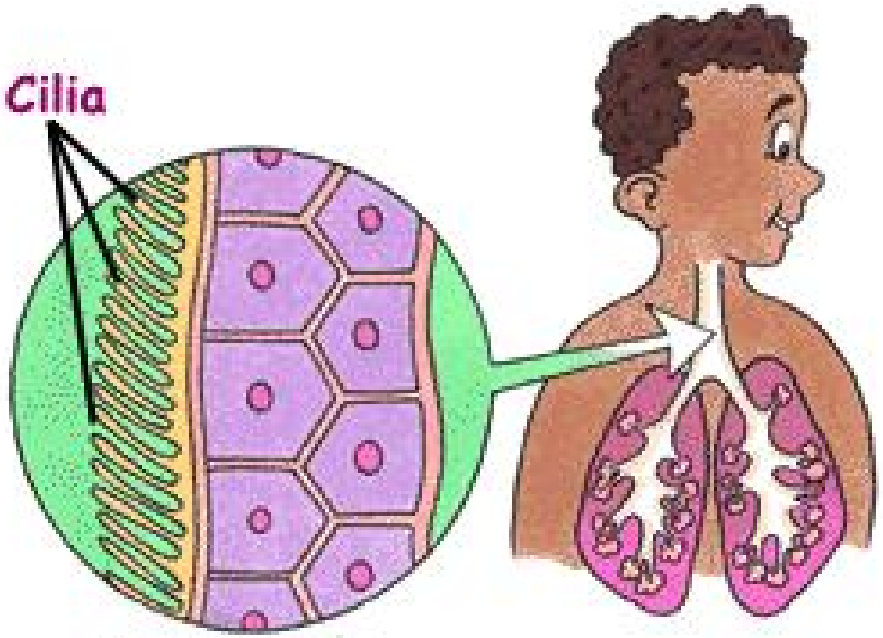
Cilia and Flagella

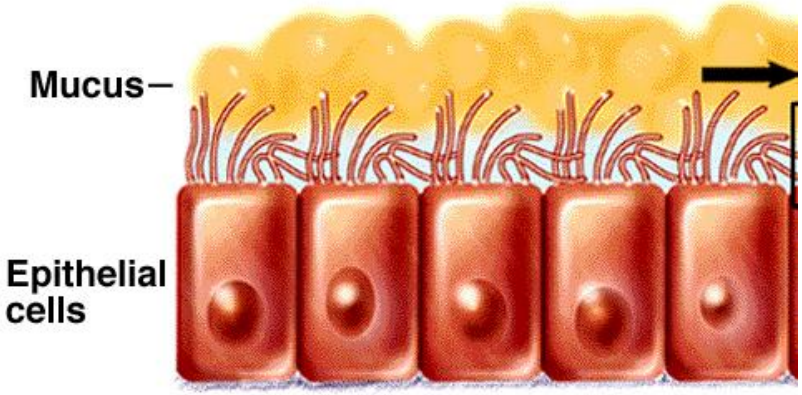
- Axoneme- structural basis for ciliary movement
  - Consist of an array of thin protien cylinders called microtubles
  - There are two centrally microtubules surrounded by a ring of nine microtubule pairs (9+2 structure)
  - Dynein arms-a motor protein who's movement causes cilia to bend

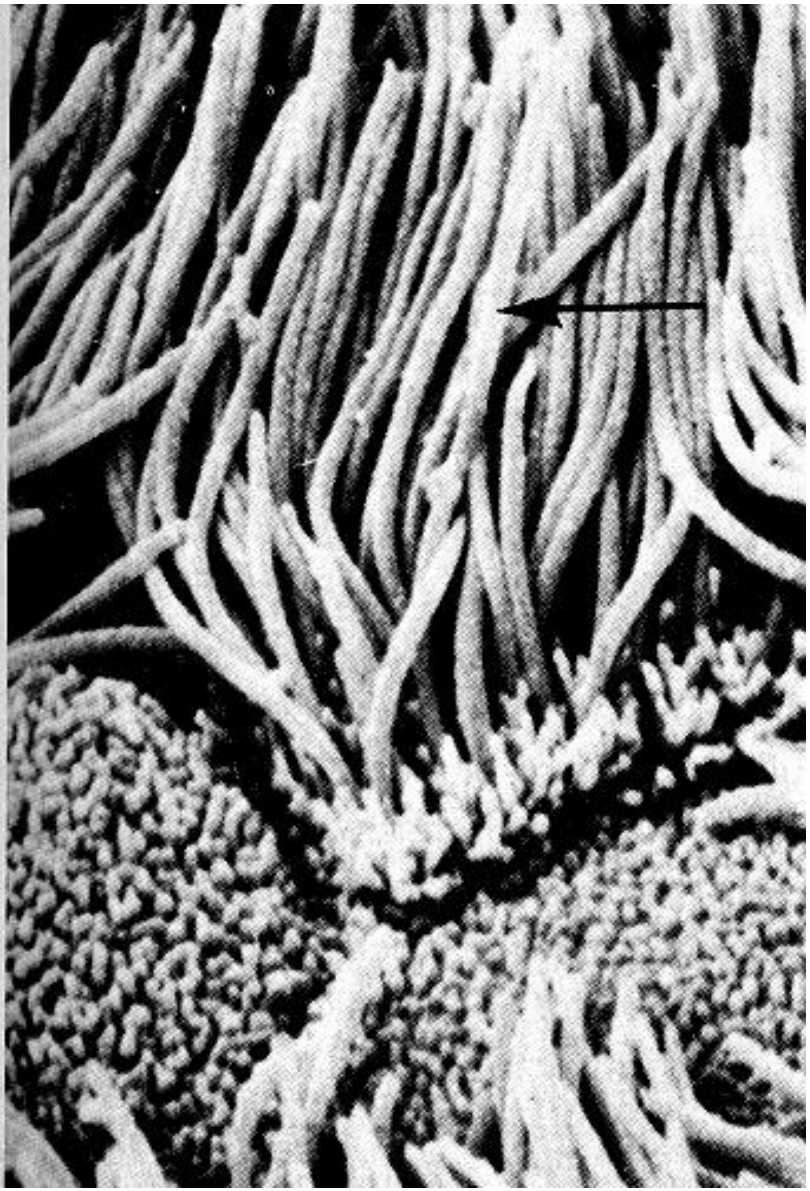


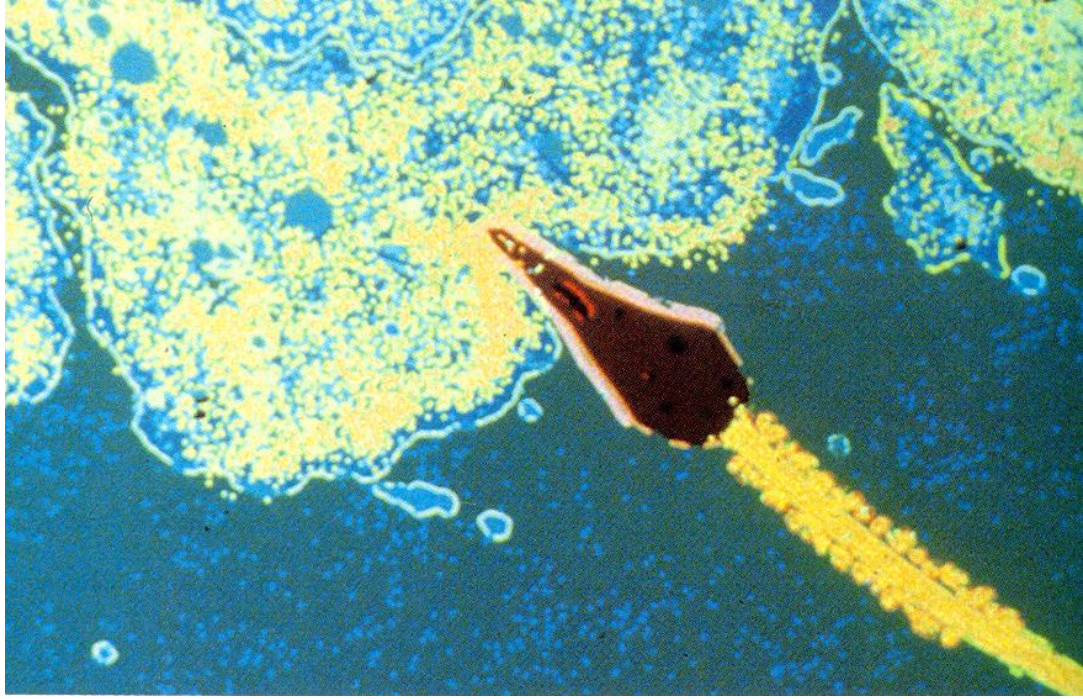
Cilia In The Lungs

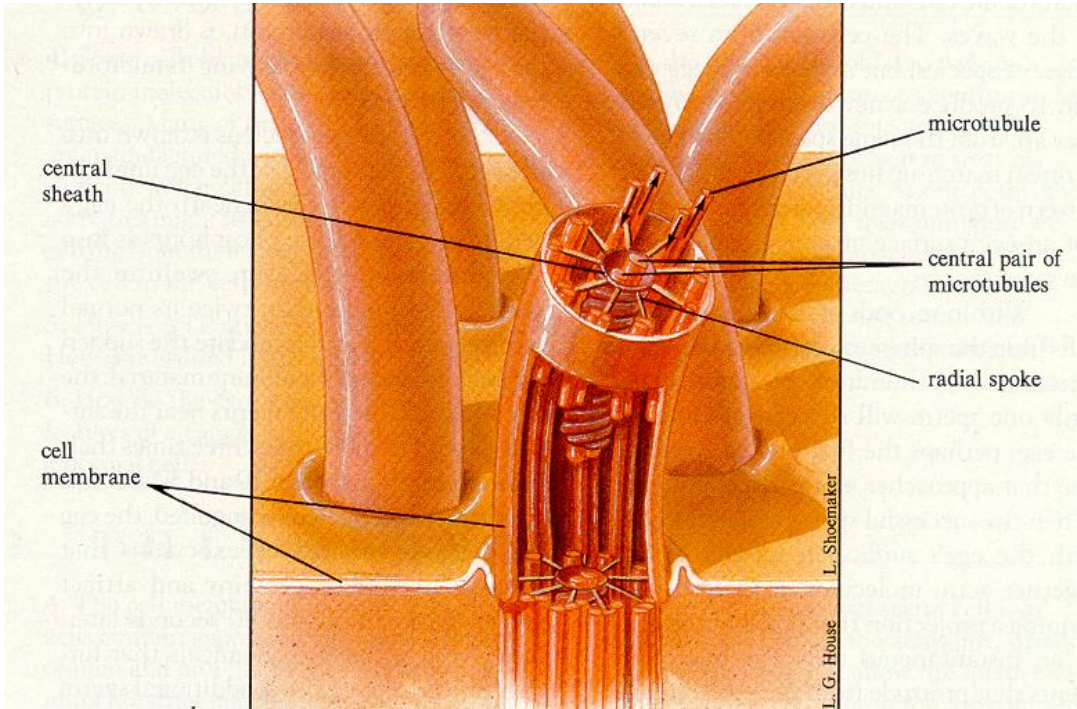
- Sweeps dust and germ laden mucous from the lung passageways to the throat to be swallowed.
- Cigarette smoke slows down and then stops the action of cilia.





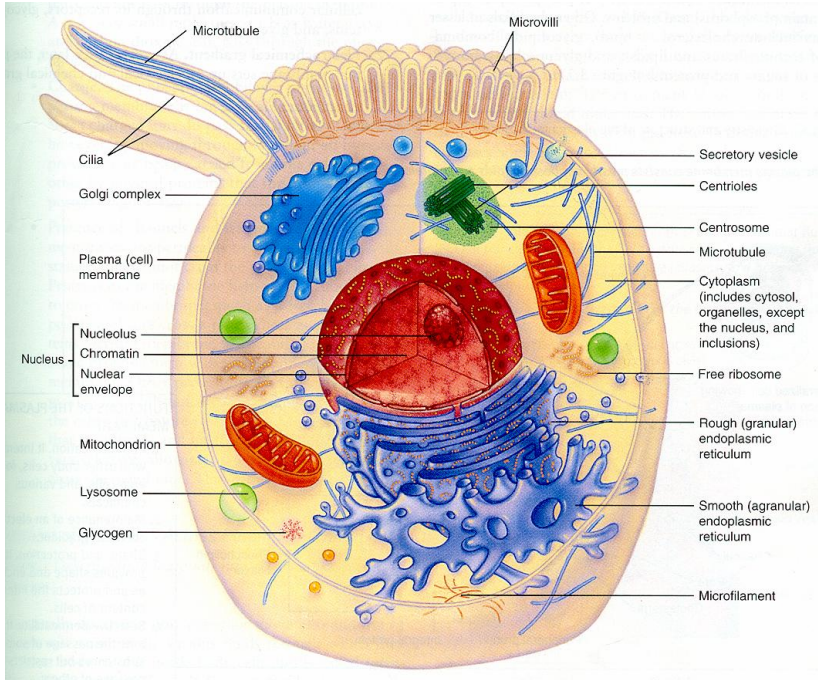


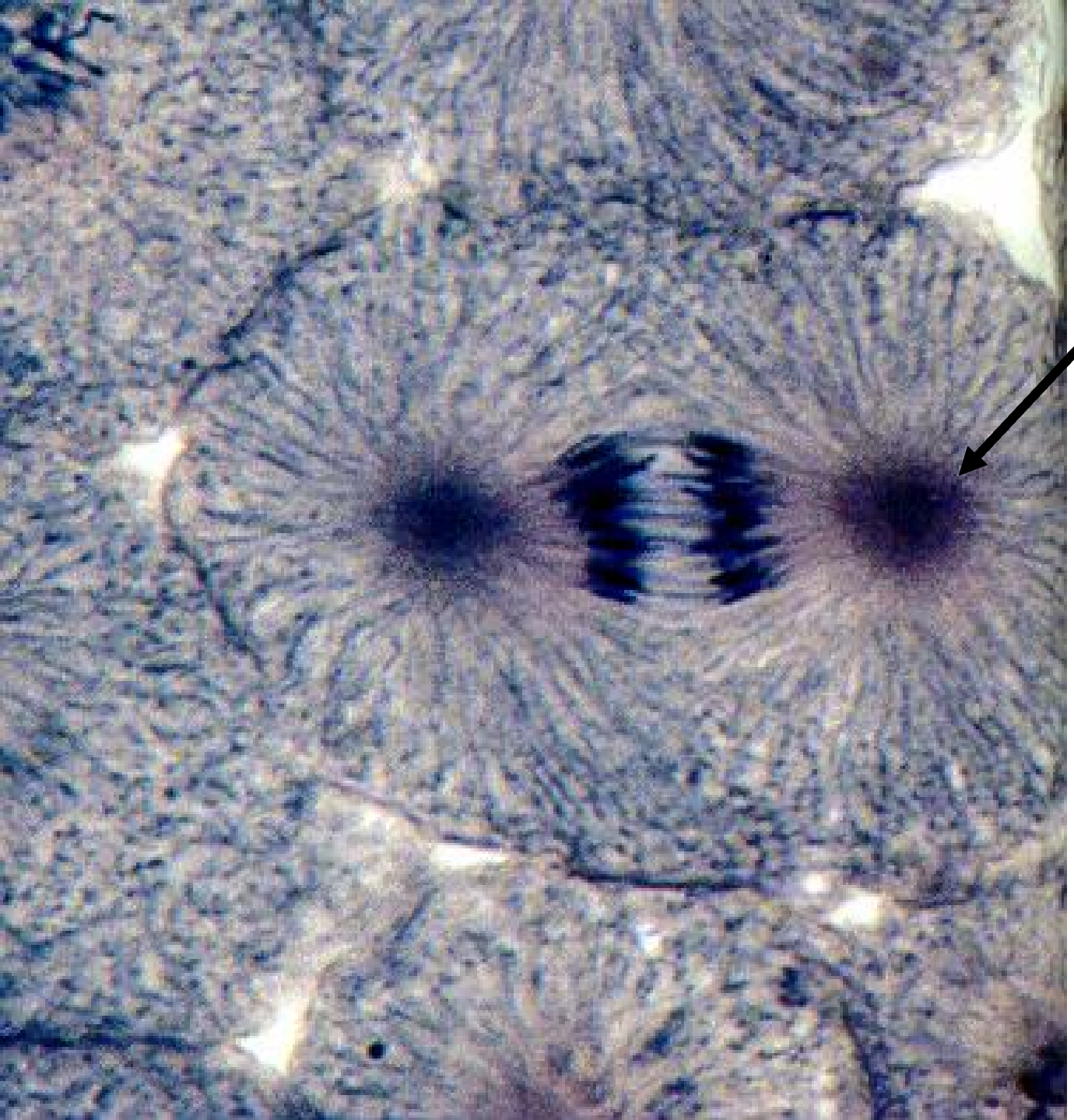



central sheath
microtubule
central pair of microtubules
radial spoke
cell membrane
L. Shoemaker
L. G. House

Centrosome and Centrioles

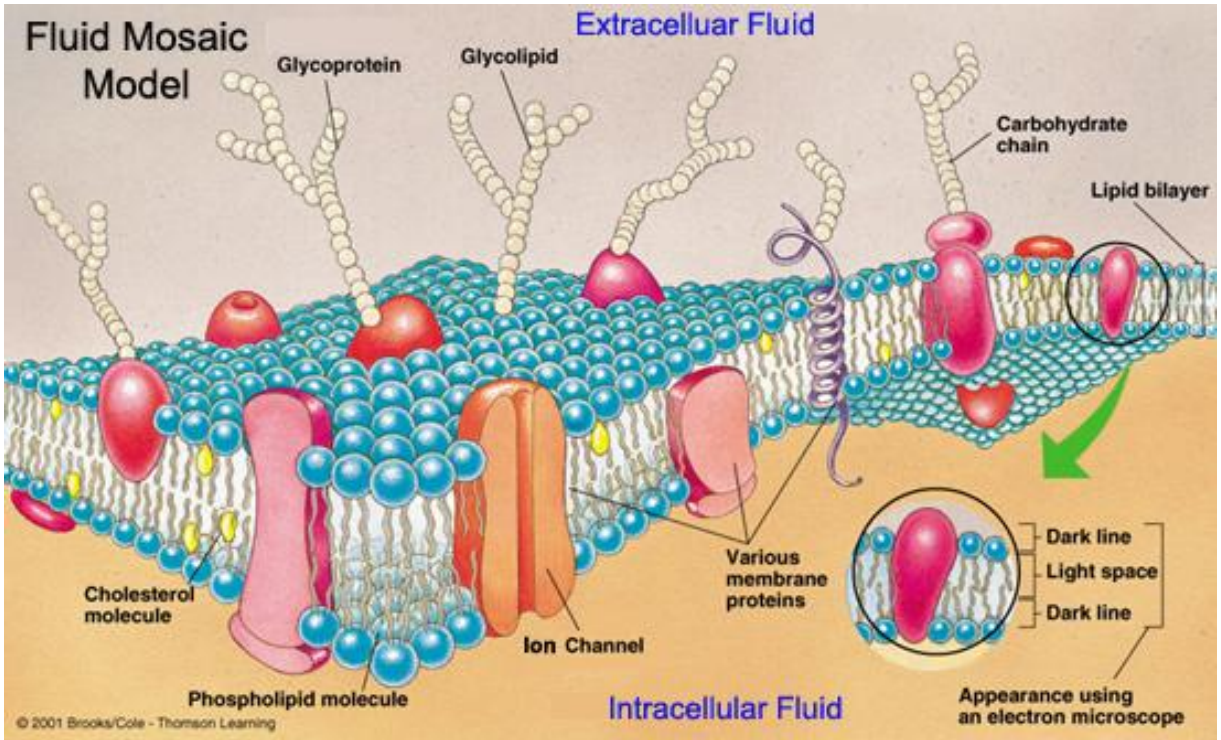
- Centrosome- a dense area of cytoplasm near the nucleus that is involved in mitosis
- Centrioles- a pair of structures composed of microtubules arranged in right angles that are located in the centrosomes.
  - Has an unknown function in mitosis
  - involved in the formation of flagella and cilia




centrosome

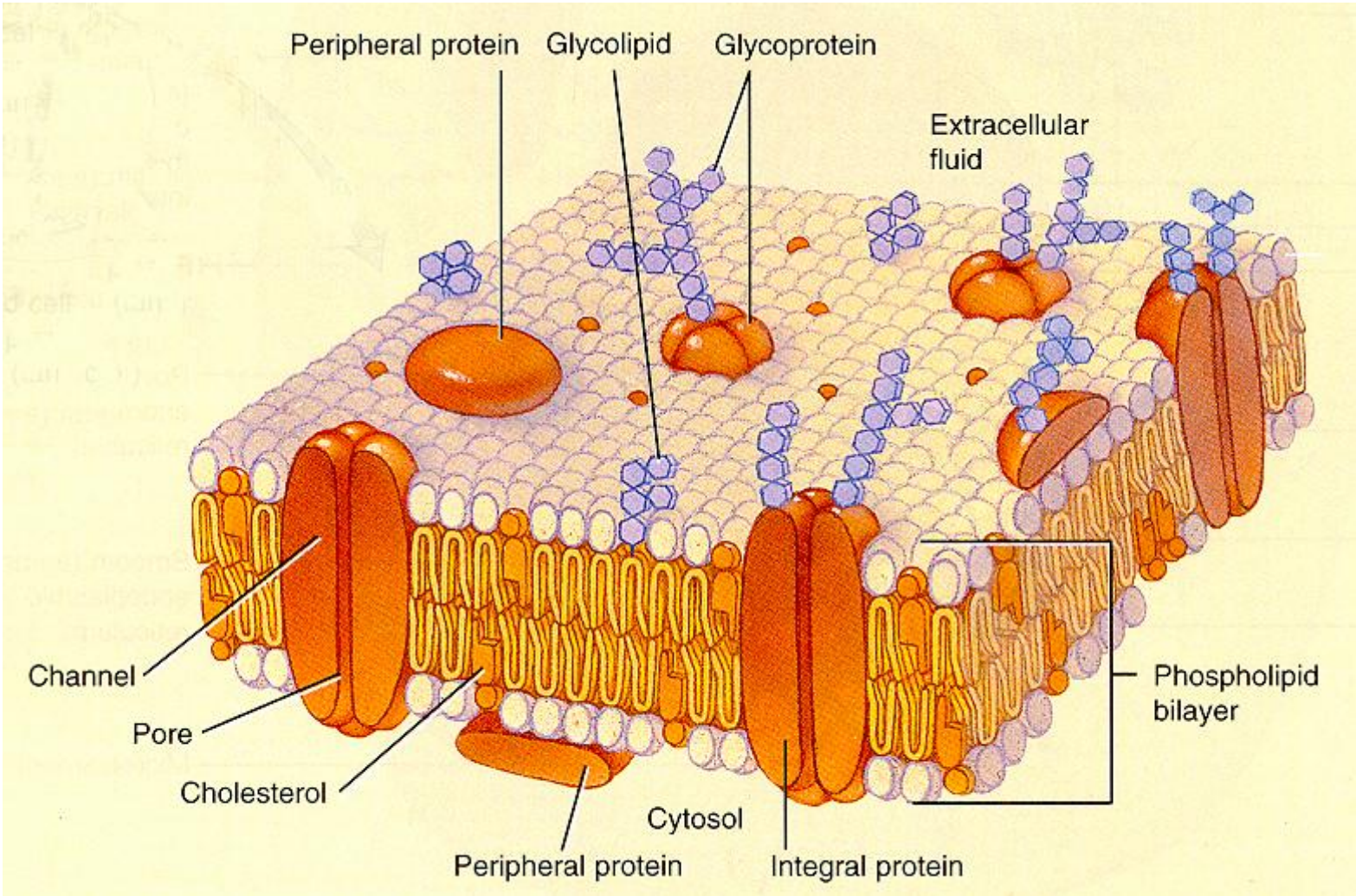
Plasma Membrane

- Composed of two parallel rows of phospholipids called a phospholipid bilayer.
- Contains two types of membrane proteins
  - integral- penetrate through the membrane
    - form channels that have pores through which certain substances move in and out of the cell.
    - transporters (carriers) that move substances from one side of the membrane to the other.
    - Receptors (recognition sites) which identify and attach various molecules (i.e. hormones, antibodies.. etc.).
    - cell identity markers-glycoproteins and glycolipids that enable the cell to recognize self and foreign.
  - peripheral - loosely attached to the exterior or interior surface of the membrane



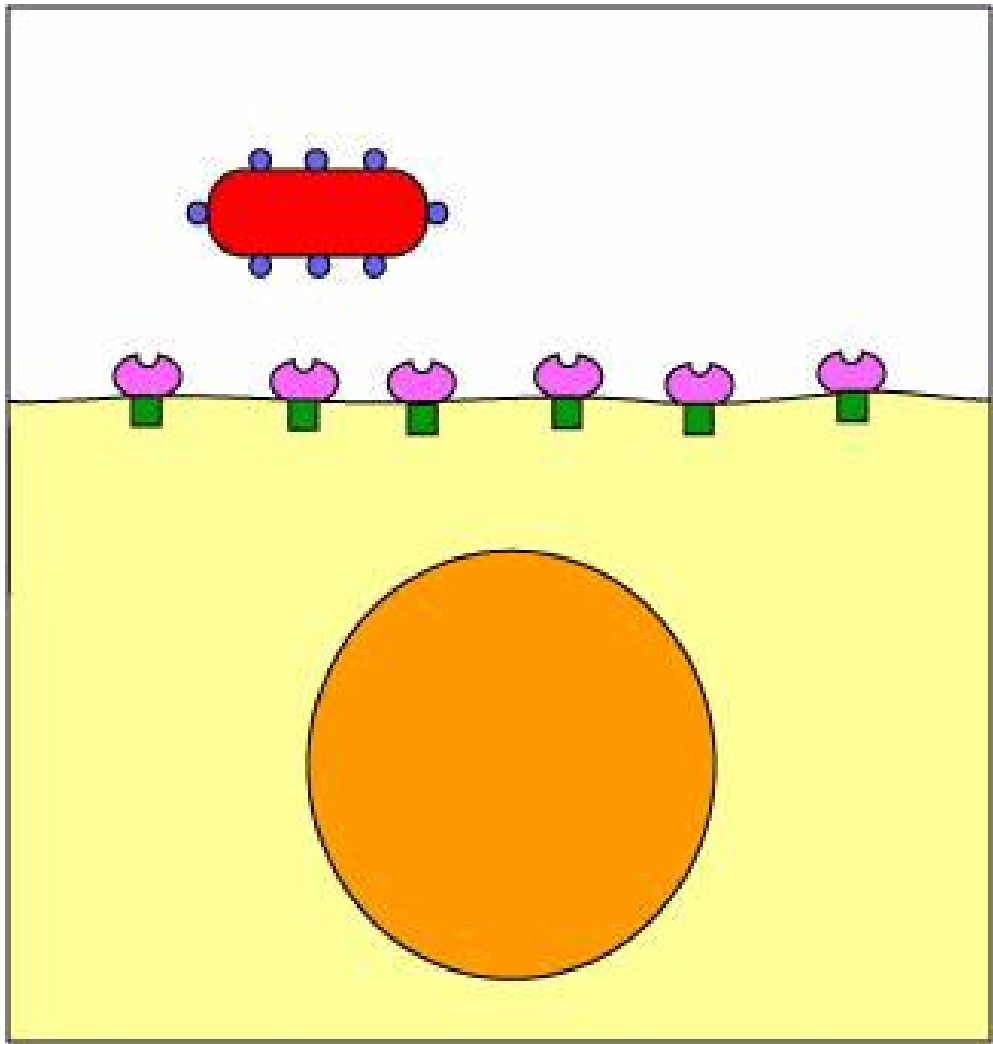
Functions of the Plasma Membrane

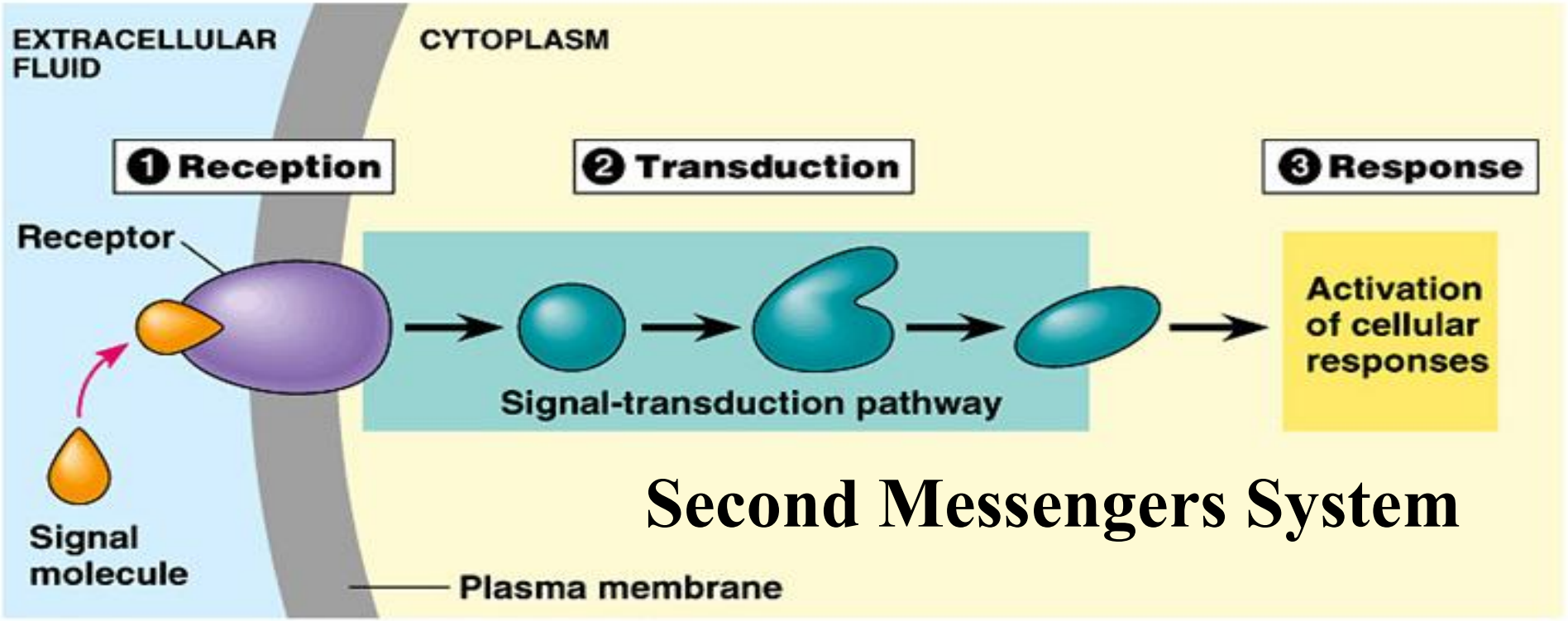
- Shape and protection



Functions of the Plasma Membrane

- Communication- occurs via receptors and second messengers
- Enzymes in the membrane break down signaling molecules to halt action





Second Messengers System

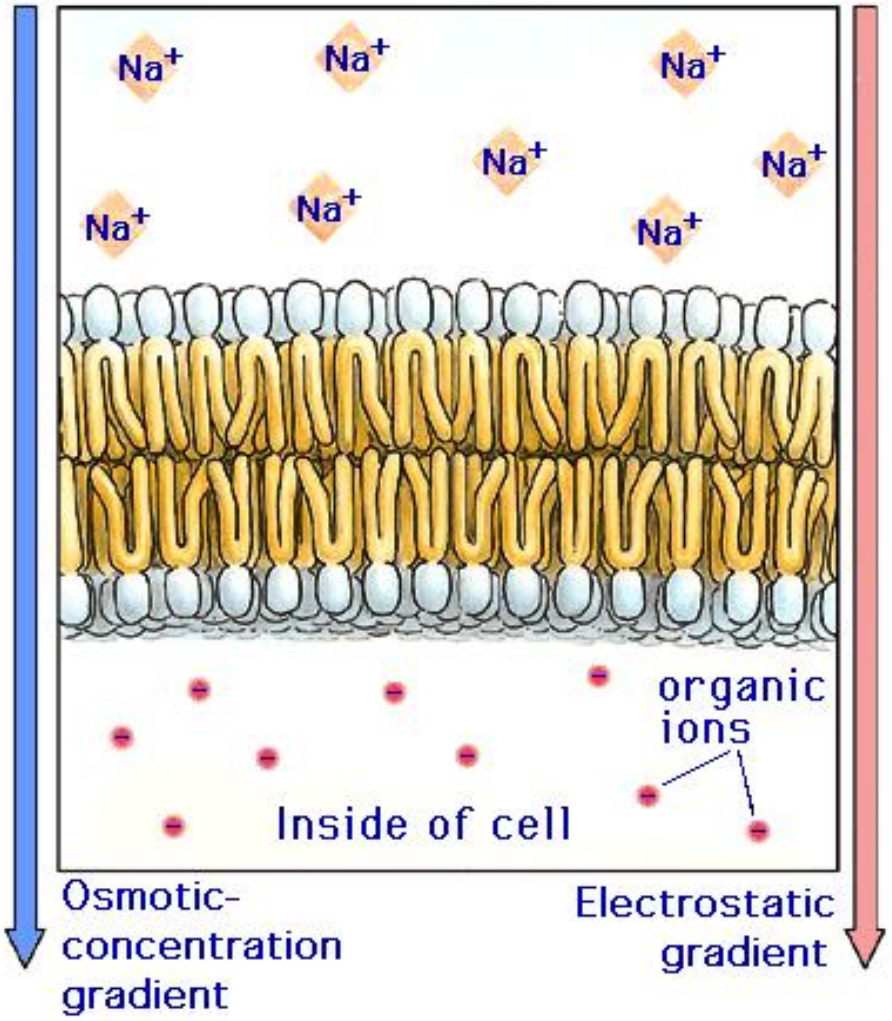
Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

- **Reception**- ligand molecules are recognized by only one receptor protein bound within a cell membrane
- **Transduction**- leads to a conformation change in receptor
  - shape change results in receptor interacting with other intra-cellular molecules resulting in multiple, structural changes in other cellular proteins

    Ex: inactive enzymes ---> active enzymes
- **Response**- usually a cellular activity, as enzyme catalysis, or the rearrangement of cytoskeleton (movement), or specific gene activity.

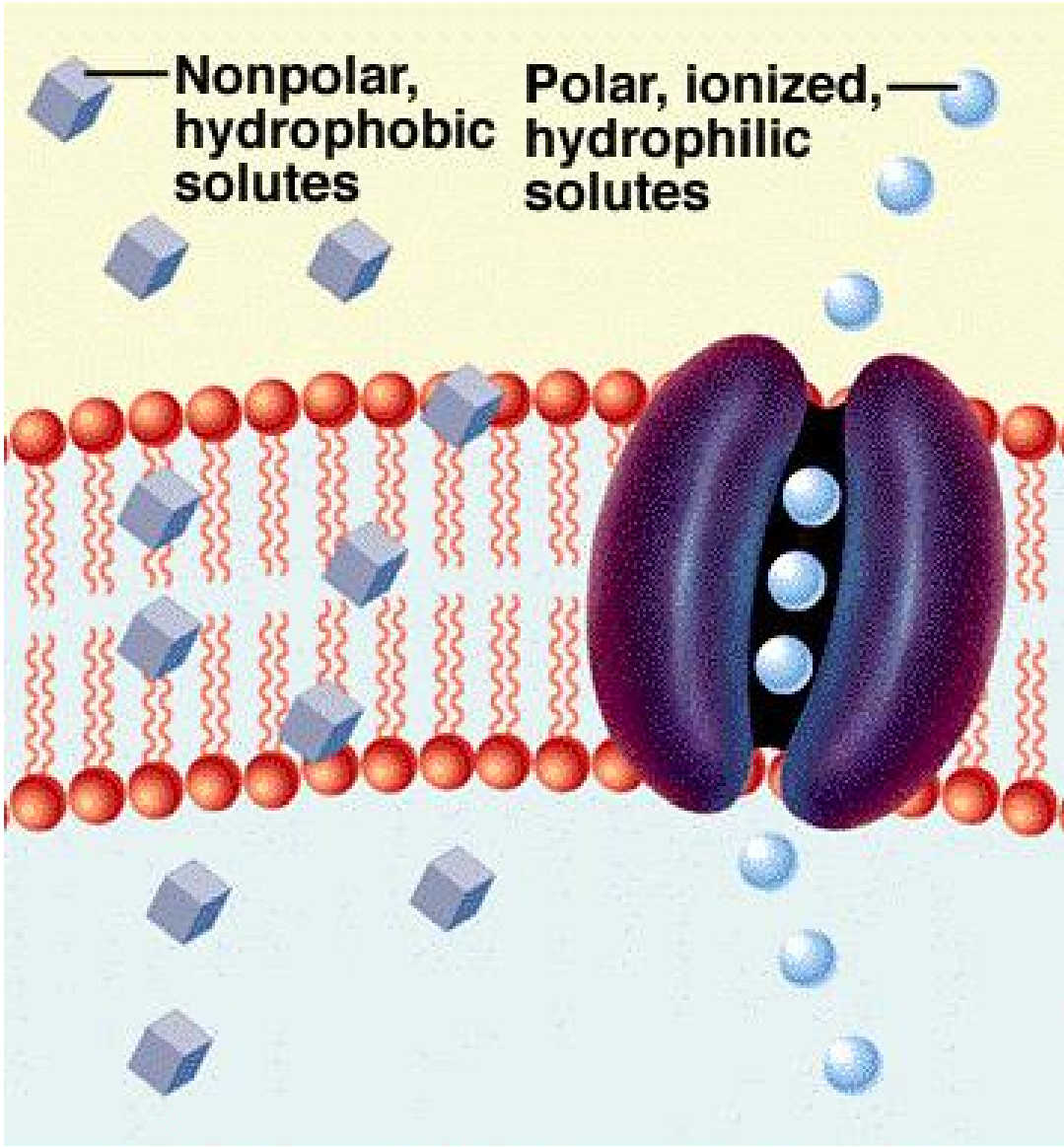
Functions of the Plasma Membrane

- Maintains the electrochemical Gradient



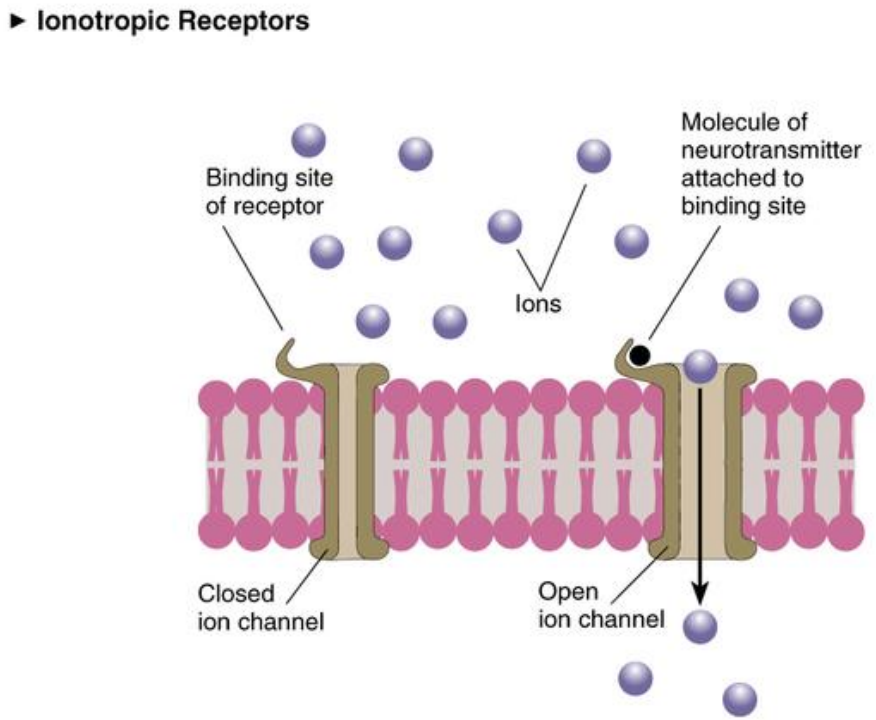
Functions of the Plasma Membrane

- Selective permeability- regulation of the entry and exit of materials
  - depends on various factors
    - lipid solubility- substances that dissolve in lipids easily pass across membrane.
    - size- most large particles cannot pass. A few small molecules pass (CO_2, H_2O, O_2).
    - charge- impermeable to ions
    - presence of channels and transporters-



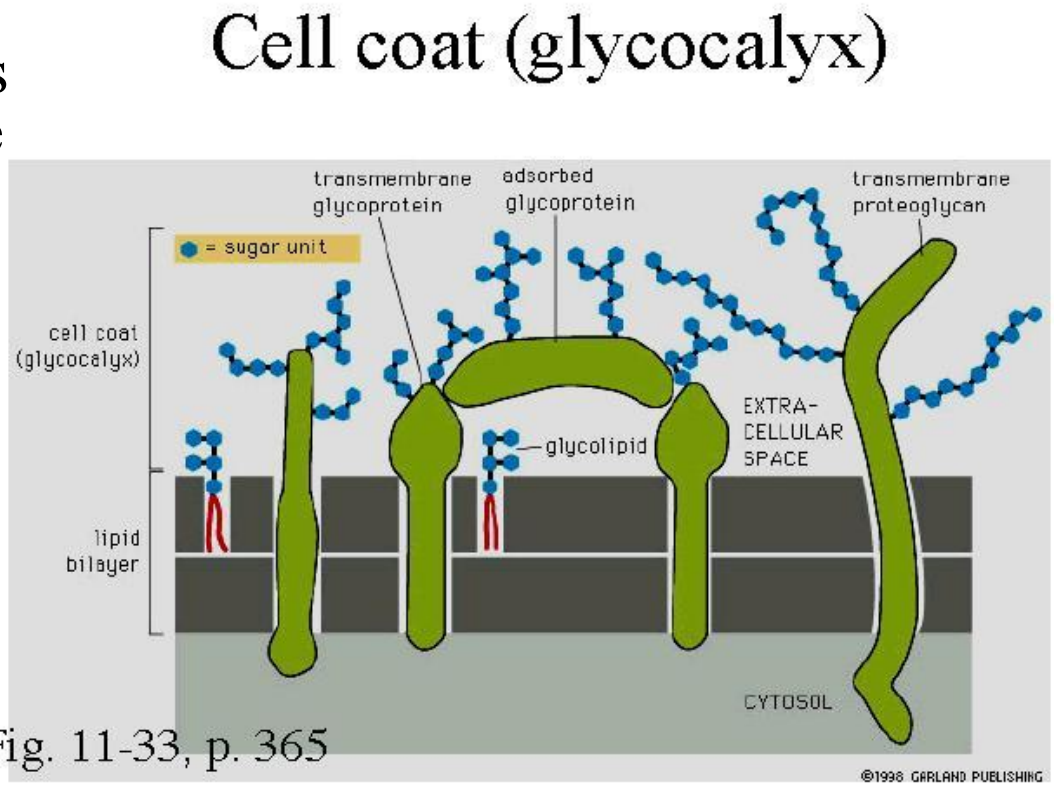
Control of Channel Proteins

- Channel gates open and close in response to three types of stimuli
  - **Ligand-regulated gates-** respond to chemical messengers
  - **Voltage-regulated gates-** respond to changes in electrical potential (voltage across the plasma membran
  - **Mechanically regulated gates-** respond to physical stress on a cell such as stret and pressure

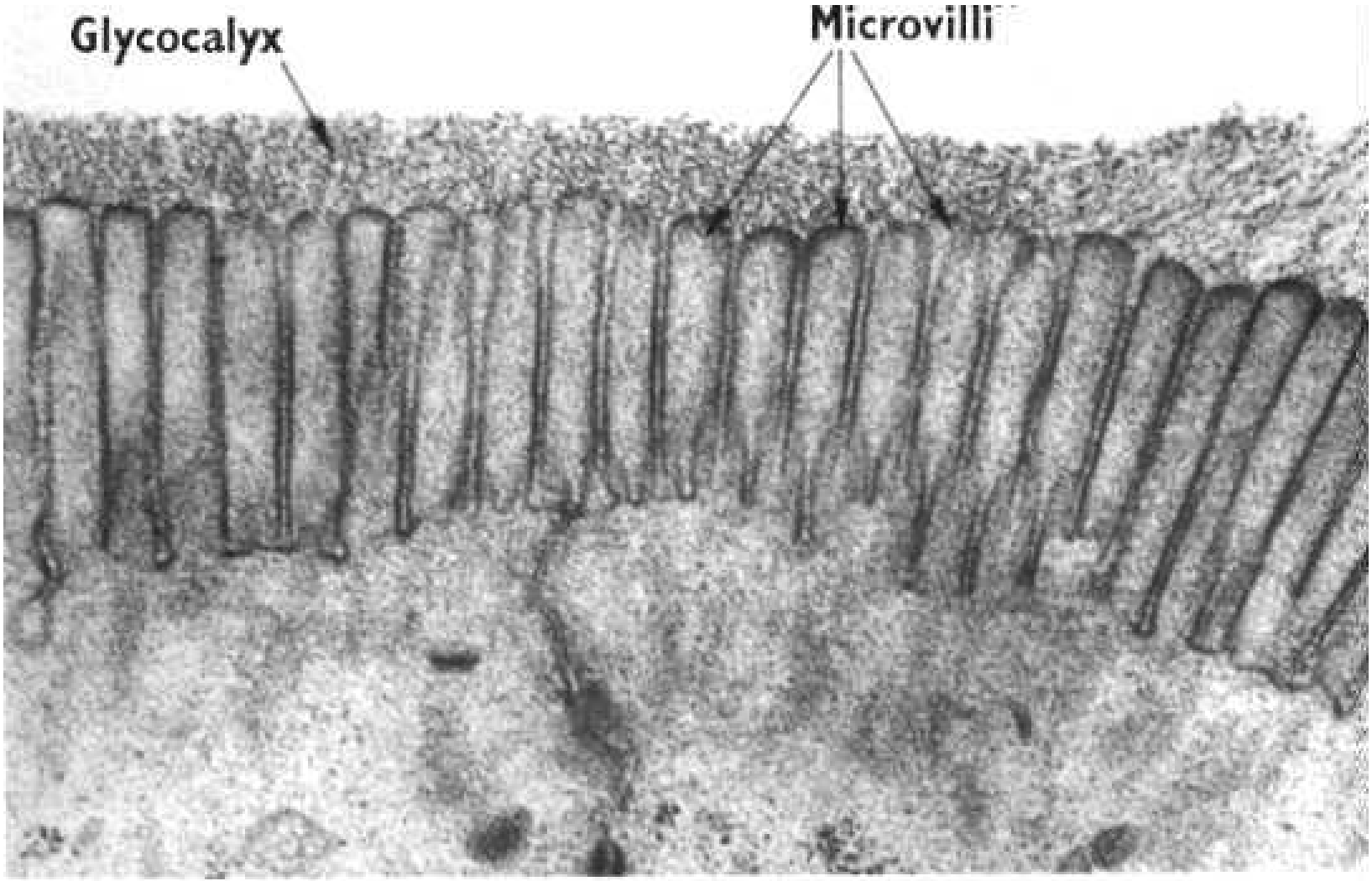


Glycocalyx

- Consist of the carbohydrate moieties of the membrane glycolipids and glycoproteins and the adhesion molecules that enables cells to adhere to each other
- **Chemically unique in everyone but identical twins**
  - **Allows the body to distinguish self form non self**

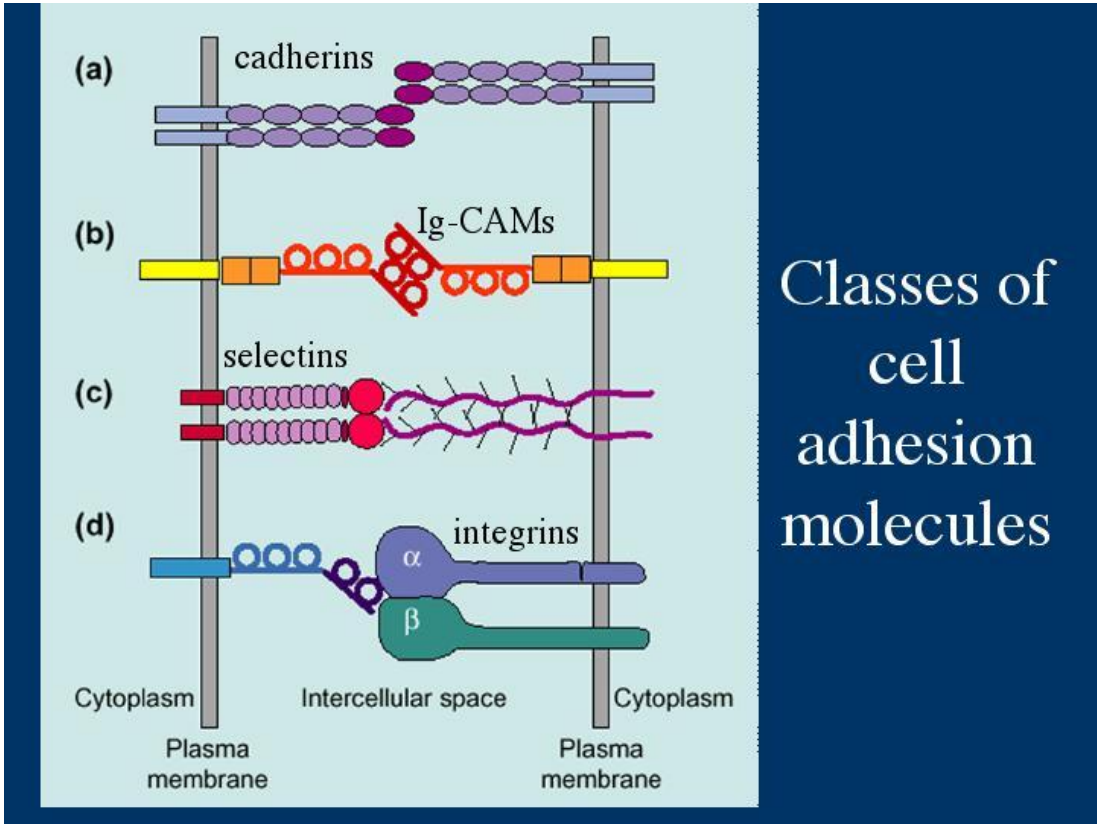


Glycocalyx



Cell Adhesion Molecules (CAMs)

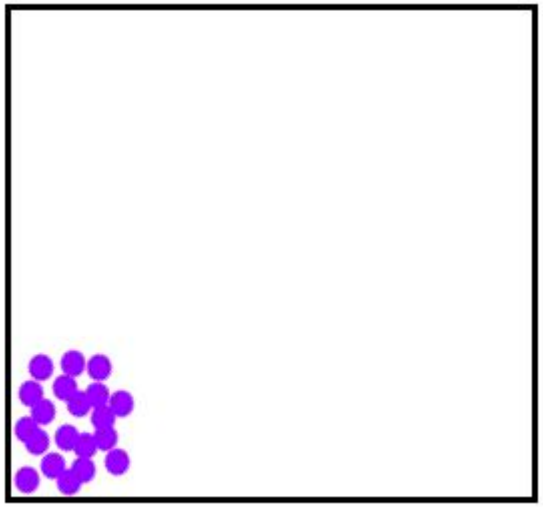
- Adheres cells to one another and to extracellular matrix
- Cells do not grow or survive unless they are mechanically linked to the extracellular matrix.
  - Acceptions- blood cells, cancer cells



Movement of Materials Across Plasma Membrane

- Passive processes (or transport)- cell does not expend energy
- Active processes (or transport)- cell expends energy

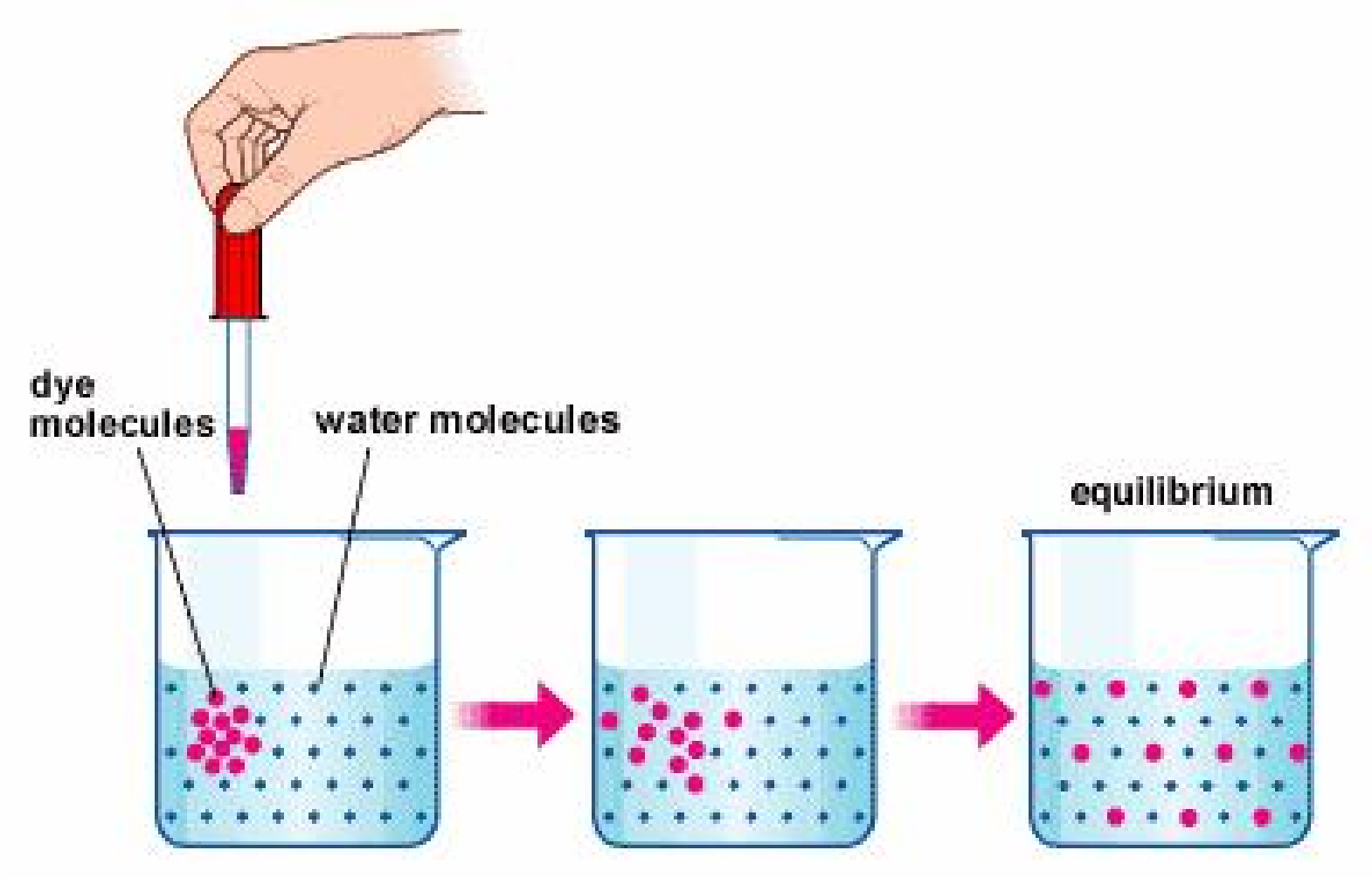
Movement of Materials Across Plasma Membrane



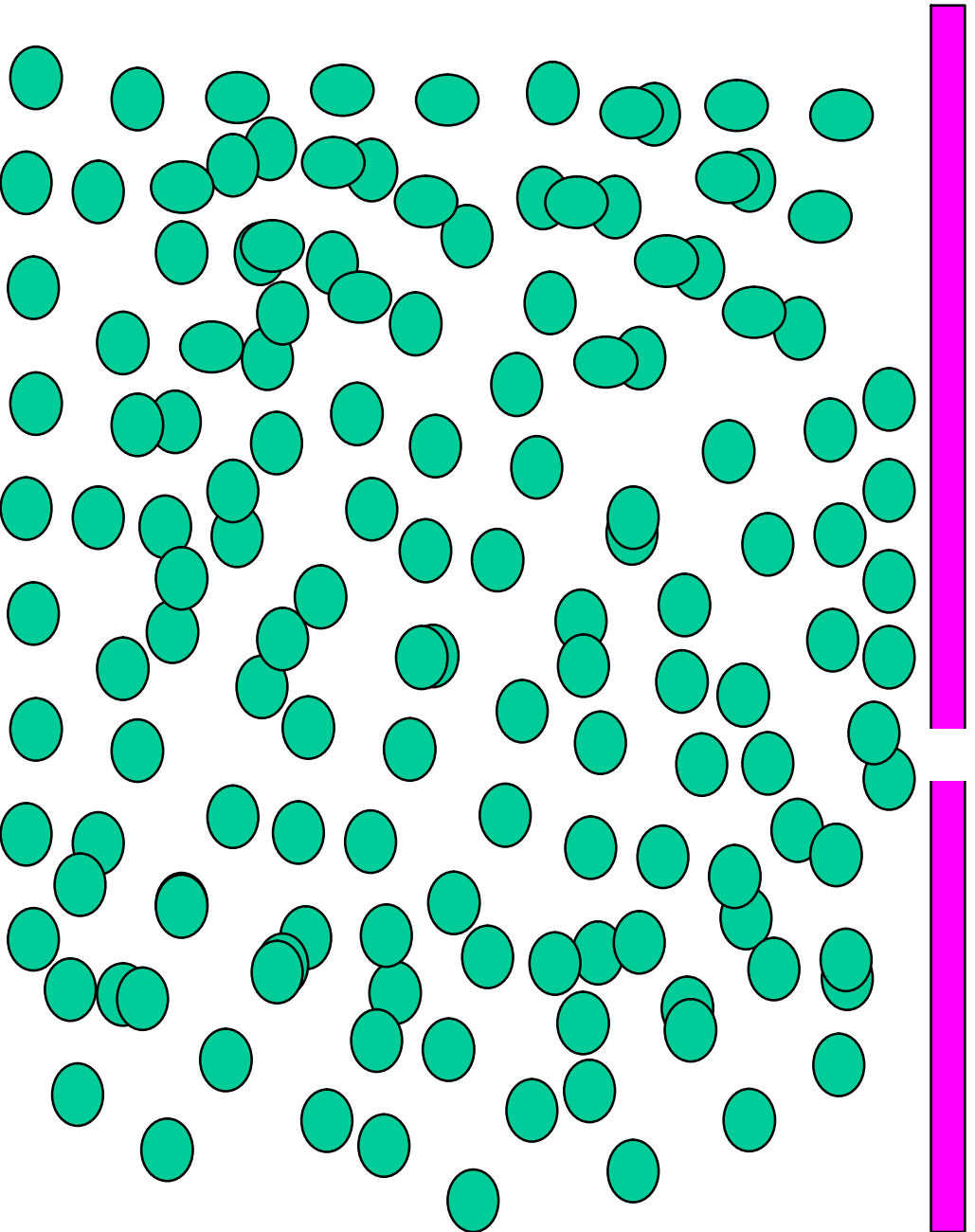
- Diffusion- the movement of substances from a place of high concentration to a place of low concentration
  - Dependent on kinetic energy (the energy of motion)

Movement of Materials Across Plasma Membrane

- Passive processes (transport)-
  - affected by
    - concentration
    - Temperature
    - Molecular weight
    - Membrane surface area
    - Membrane permeability
    - pressure exerted by gravity or other forces
  - simple diffusion
    - concentration gradient- the difference between low and high concentration
    - equilibrium- when molecules are evenly distributed

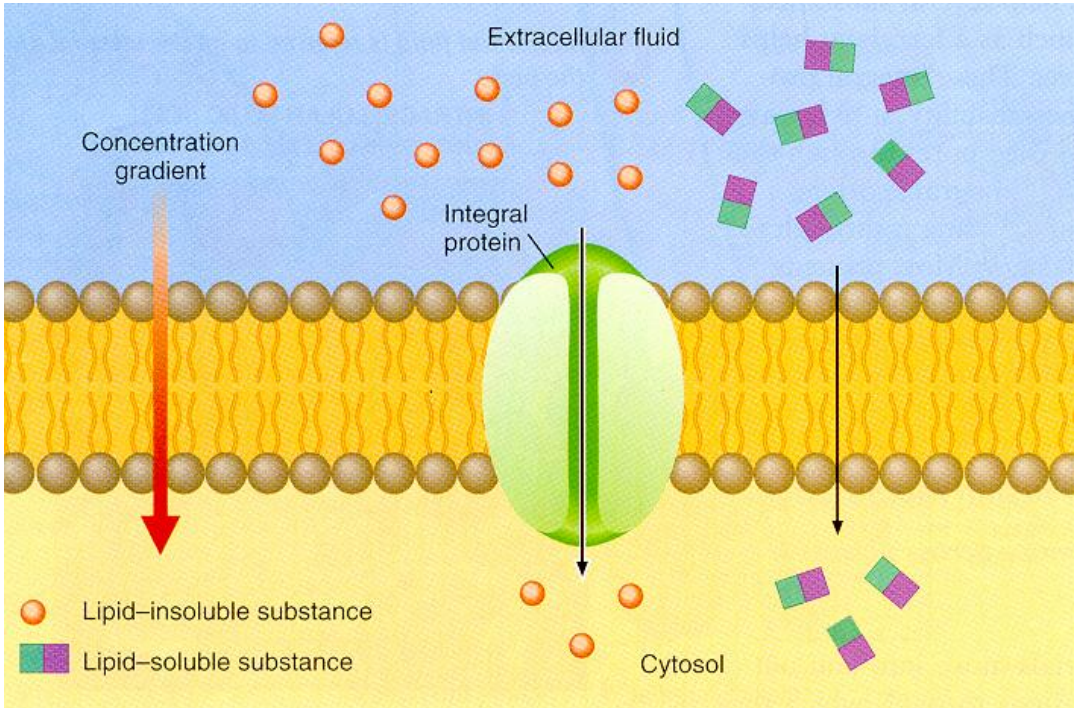

dye
molecules
water molecules
equilibrium

Passive Diffusion Across Concentration Gradient



Passive Processes (cont.)

- facilitated diffusion- when substances are allowed to cross the cell membrane with the help of integral proteins

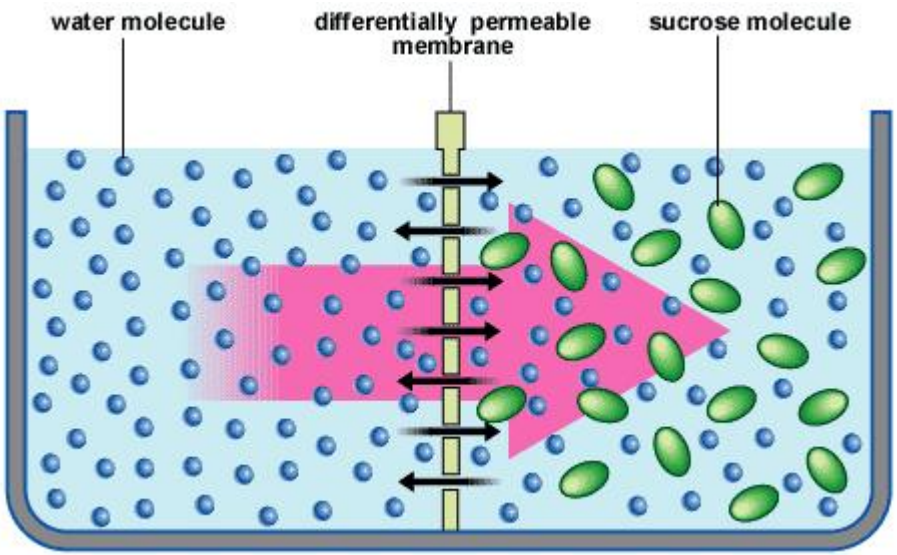


Movement of Water Across the Cell Membrane

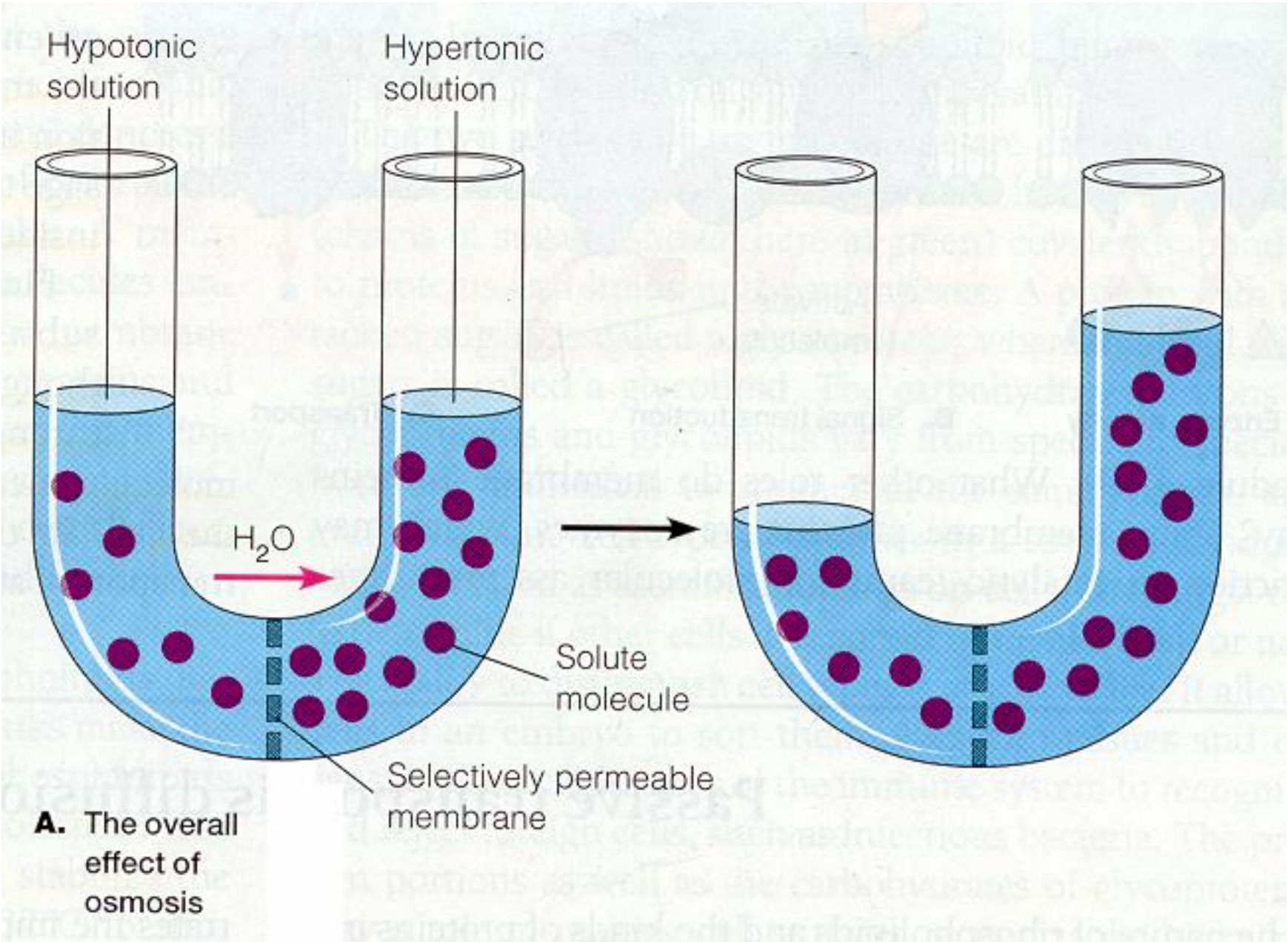
- Water crosses cell membranes by two routes:
  - by diffusion through the lipid bilayer
  - and through water channels called **aquaporins**.

Osmosis

- The special case of the diffusion concerning the movement of water across a selectively permeable membrane

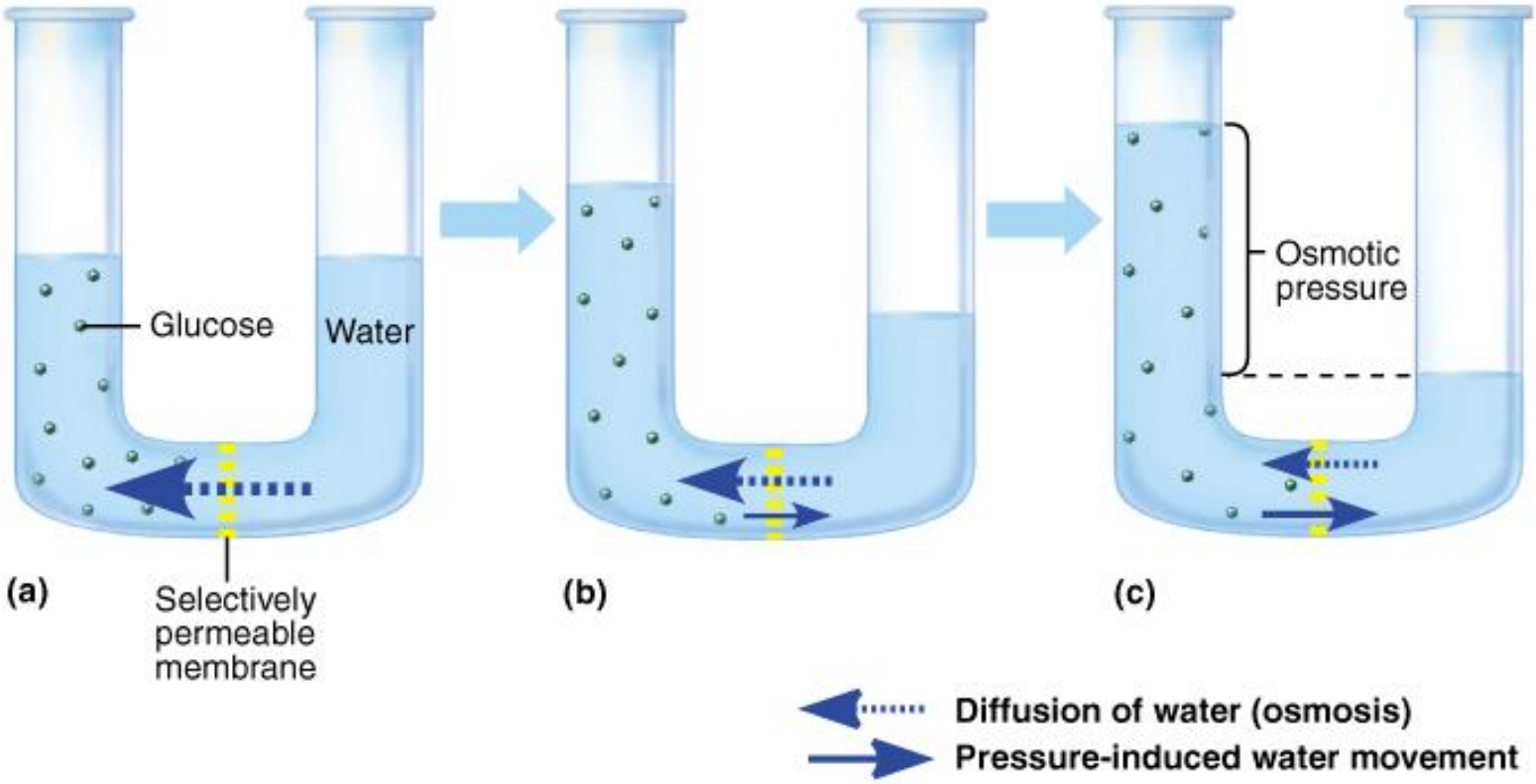


The greater the concentration gradient the greater the rate of osmosis



A. The overall effect of osmosis

- Osmotic Pressure- The force created by the tendency of water to move
- measured by the amount of pressure that stops osmosis

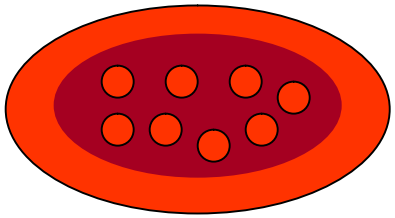


Copyright © 2001 Benjamin Cummings, an imprint of Addison Wesley Longman, Inc.

Tonicity- the ability of a solution to affect the fluid volume and pressure in a cell

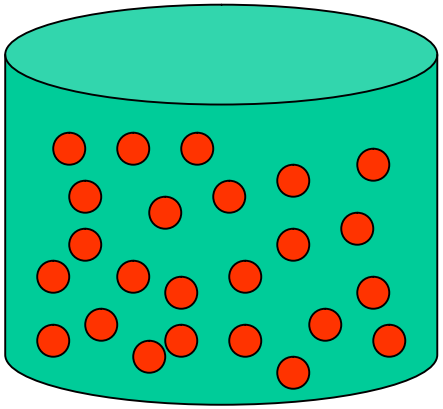
Diffusion is often discussed in reference of the particle or solute concentration instead of the concentration of water

- **hypertonic**
- **hypotonic**
- **isotonic**



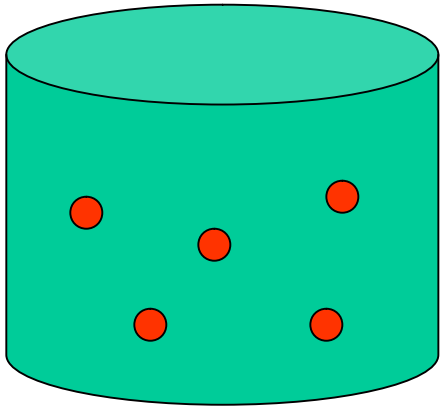
Red Blood Cell

A



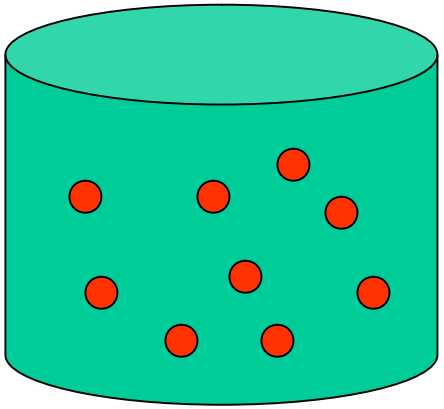
Hypertonic Solution

B



Hypotonic Solution

C



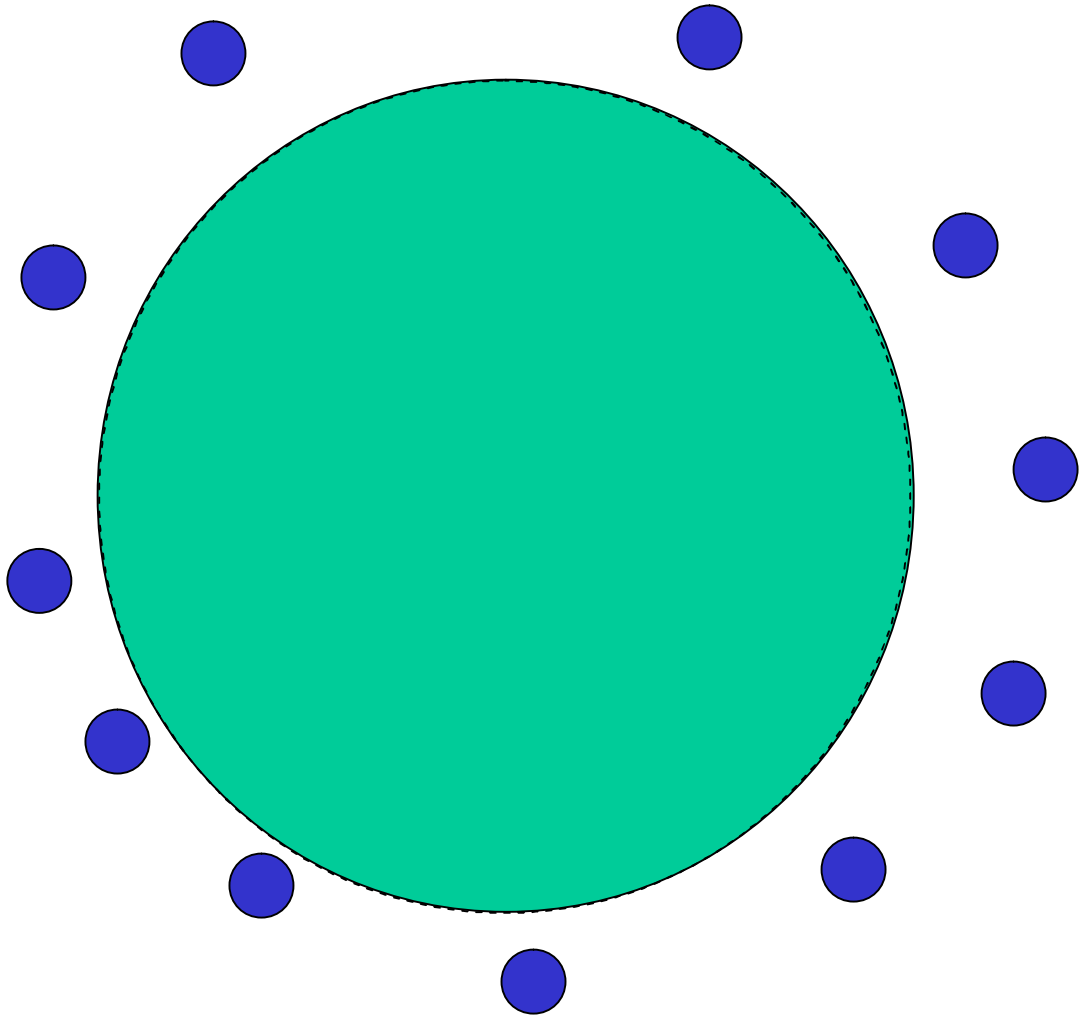
Isotonic Solution

Measuring Osmotic Concentratioan

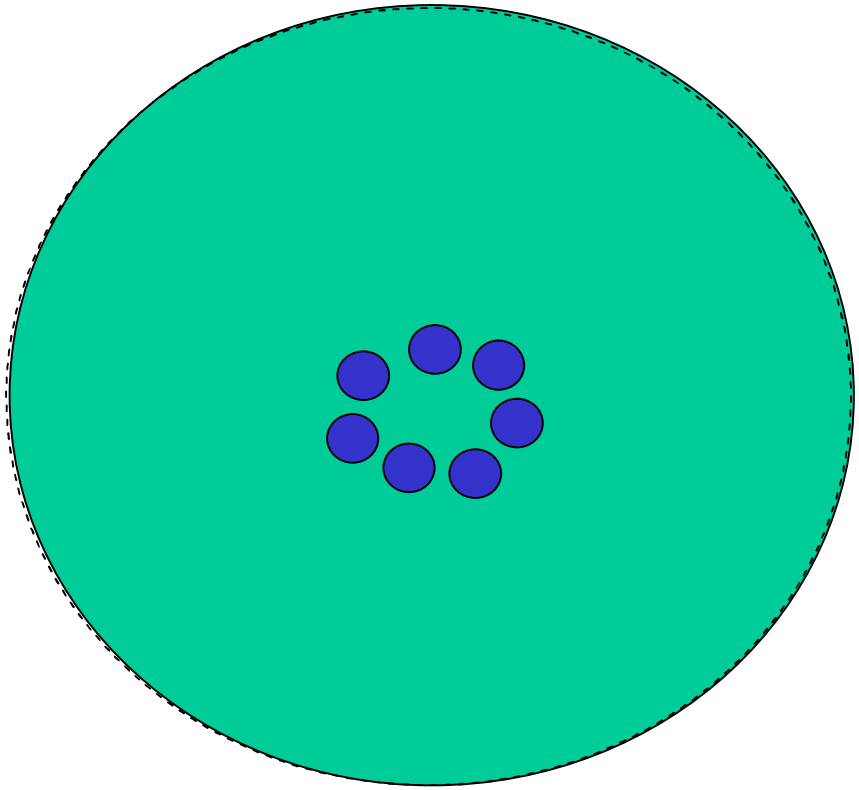
- Osmole- one mole of dissolved particles
- Osmolality- the number of osmoles of solute per kilogram of water
- Osmolarity- the number of osmoles of solute per liter of solution
- Ex: 1 M NaCl = 2 osm/L

  1 M $CaCl_2$ = 3 osm/L

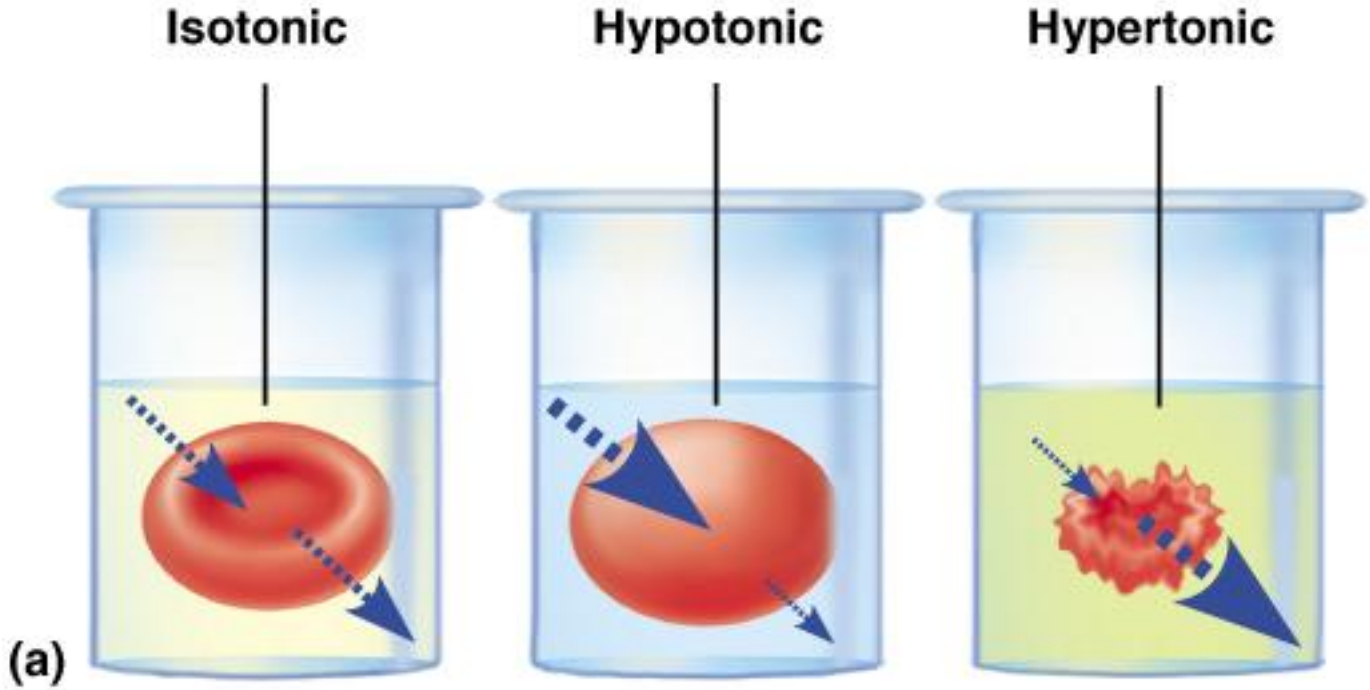
Hypotonic solution (more water)



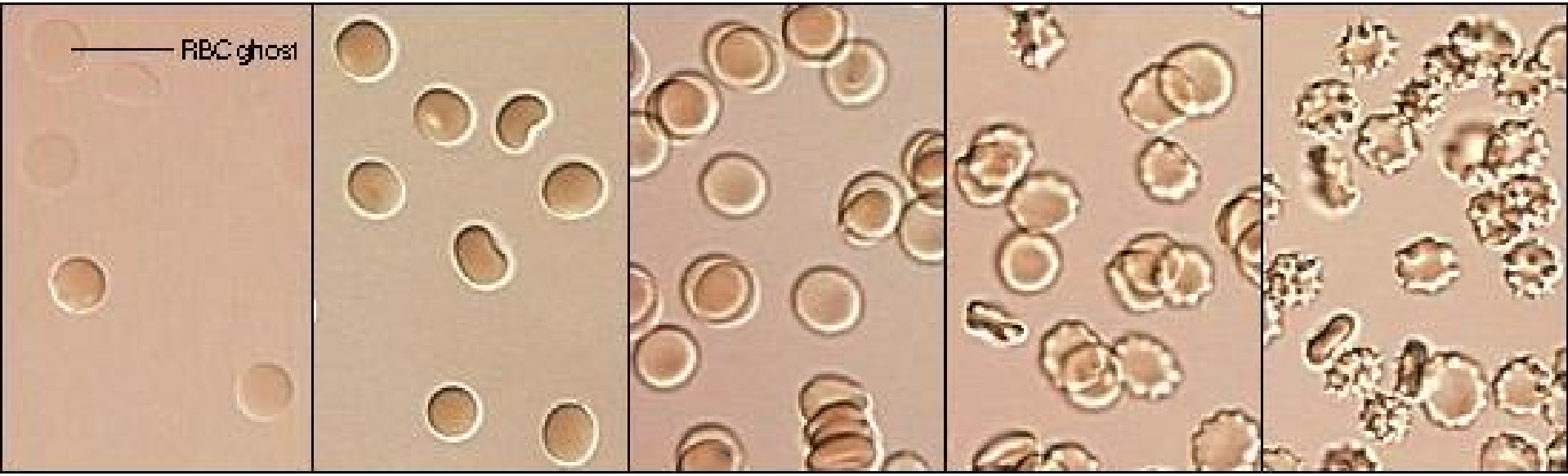
Hypertonic Solution (less water)



Effects of Blood Cell in Various Tonicity of Solutions

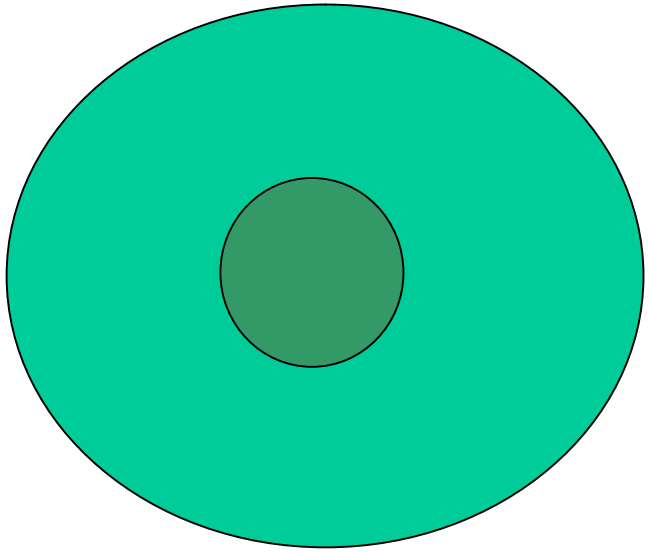


Copyright © 2001 Benjamin Cummings, an imprint of Addison Wesley Longman, Inc.



Hypotonic ← Isotonic → Hypertonic

Diffusion Of Particles From The Blood Vessels Into The Cell



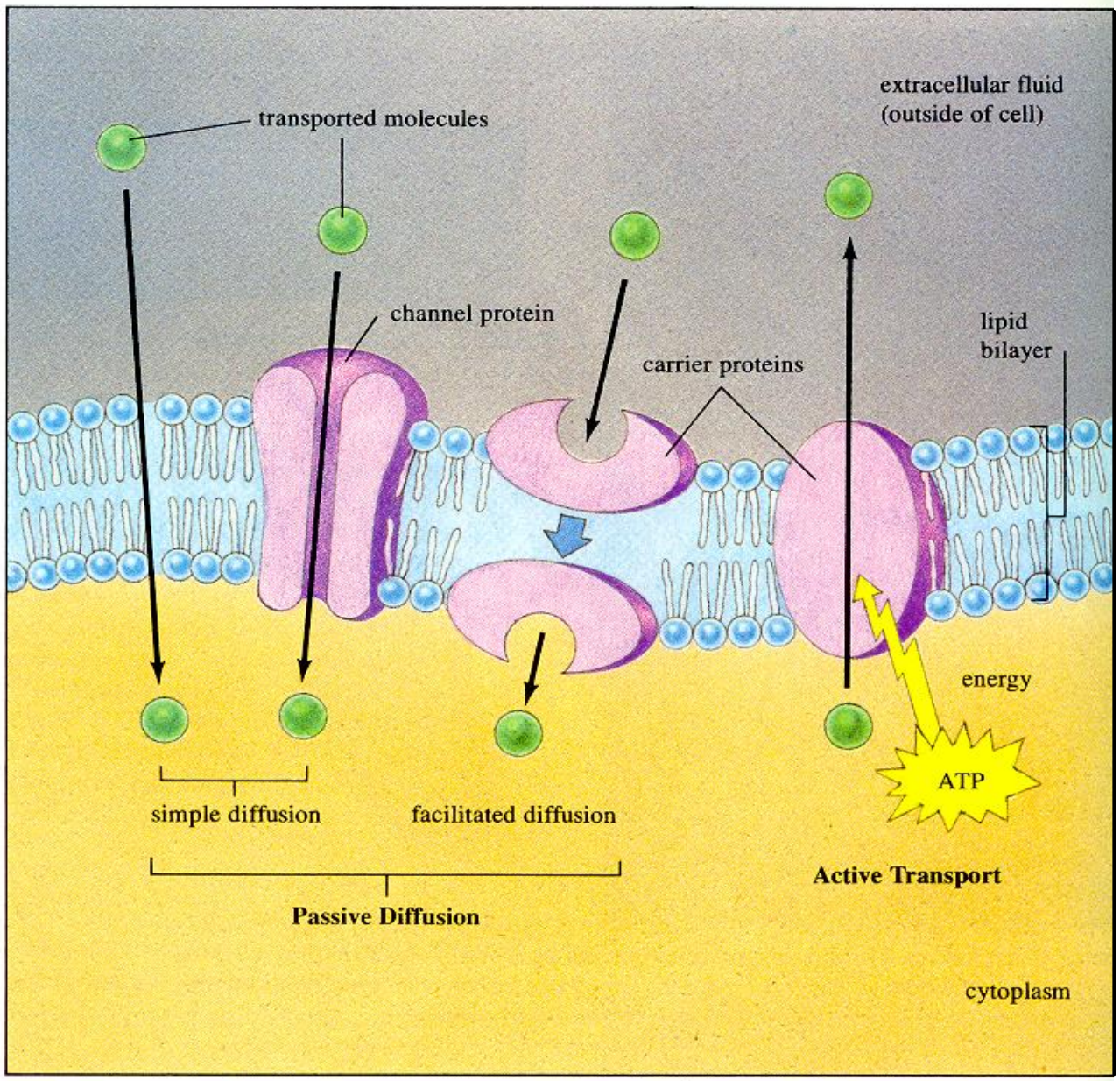
Filtration

- The movement of solvents and dissolved substances across a selectively permeable membrane by gravity or mechanical pressure (low pressure to high pressure)

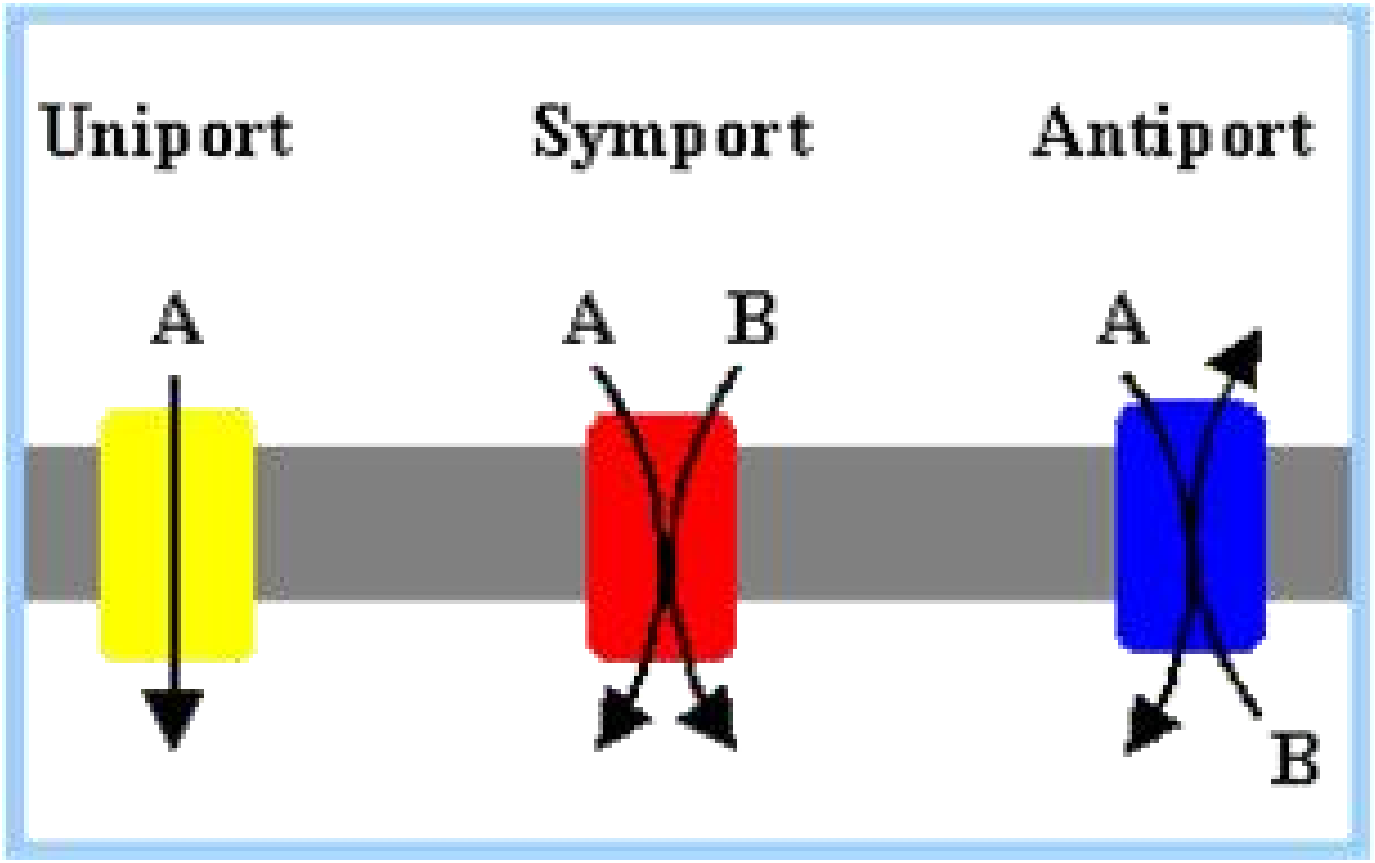
Active Processes

- The movement of substances across the cell membrane with the expenditure of energy

Active Transport

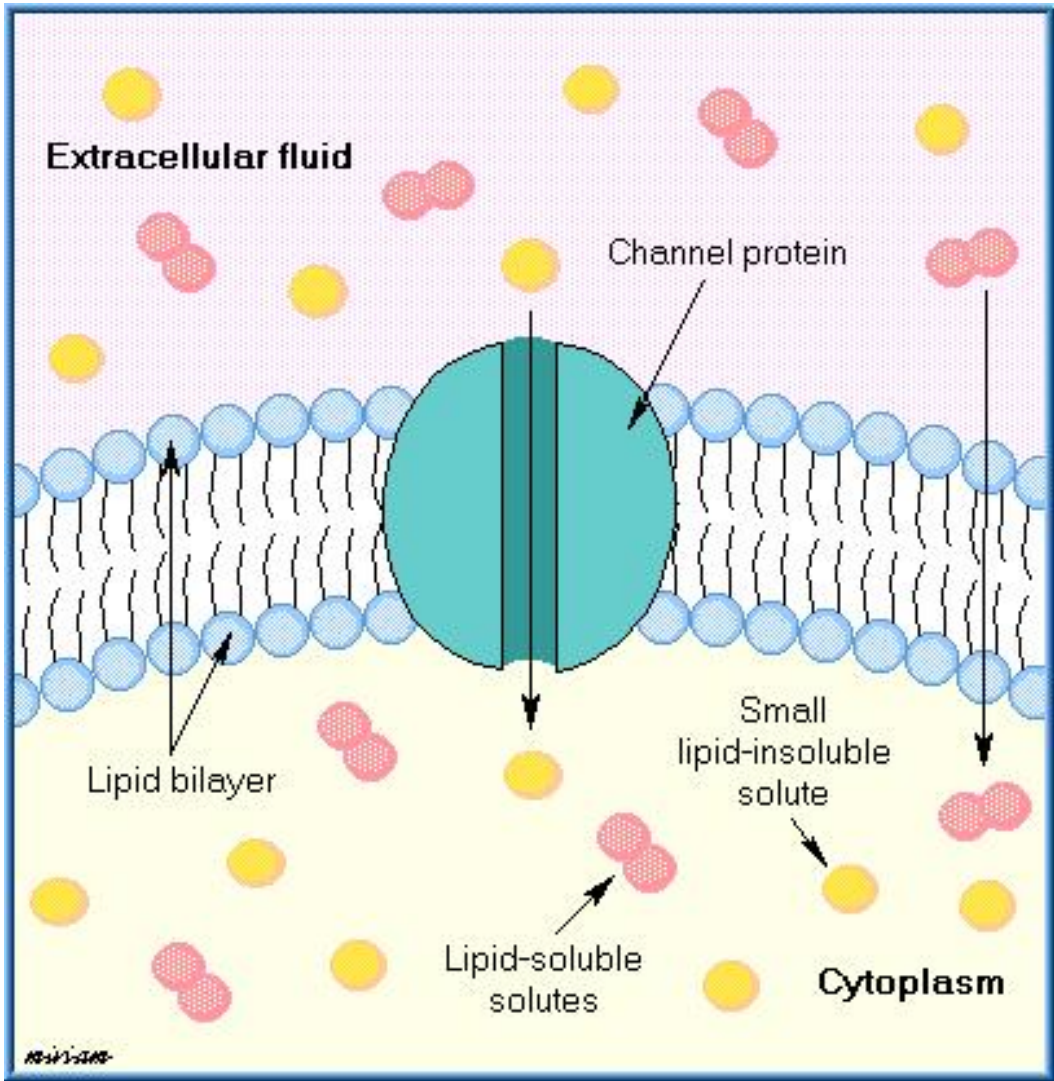


Three Kinds of Membrane Carriers



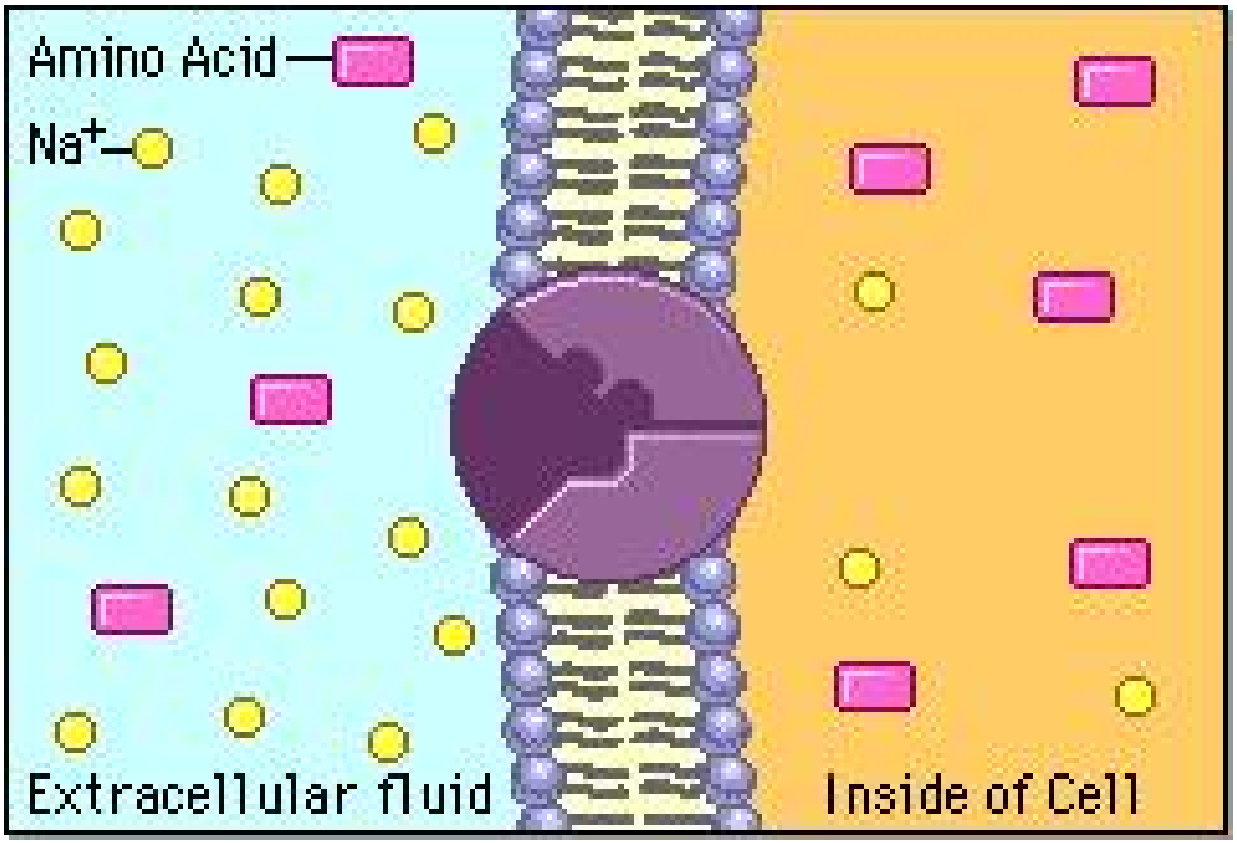
Uniport

- Carries only one molecule at a time



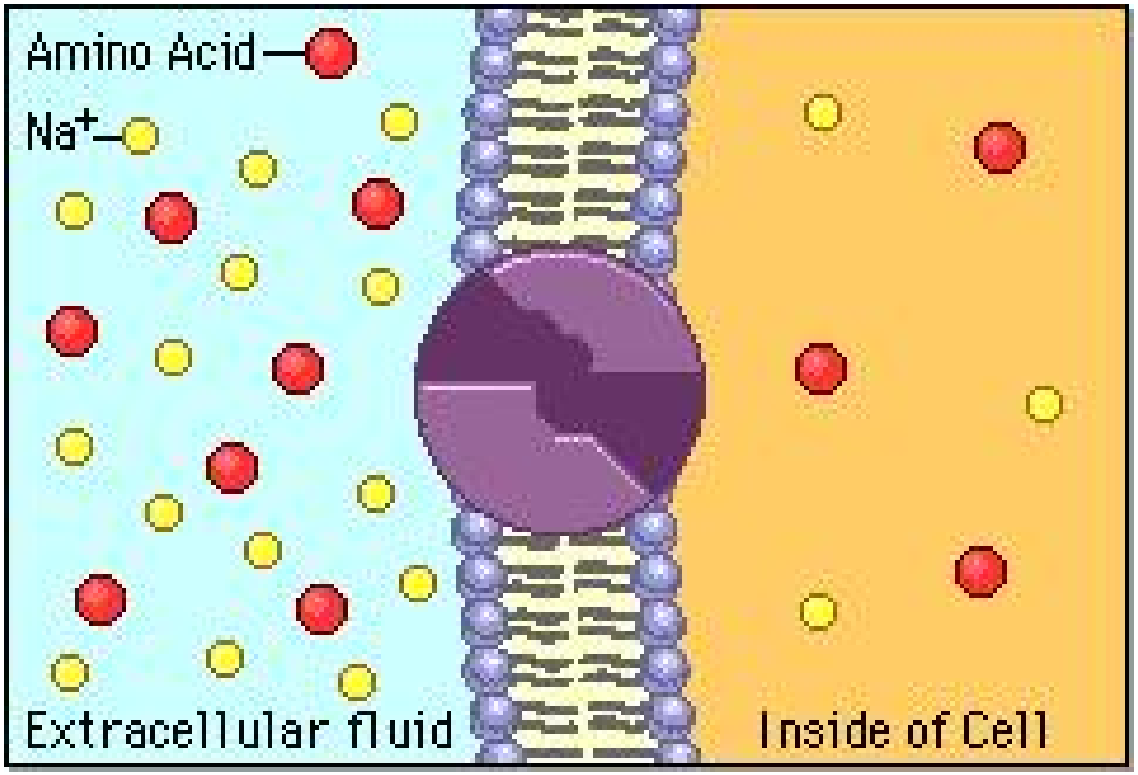
Symport

- Carries two or more solutes through a membrane simultaneously in the same direction (cotransport)



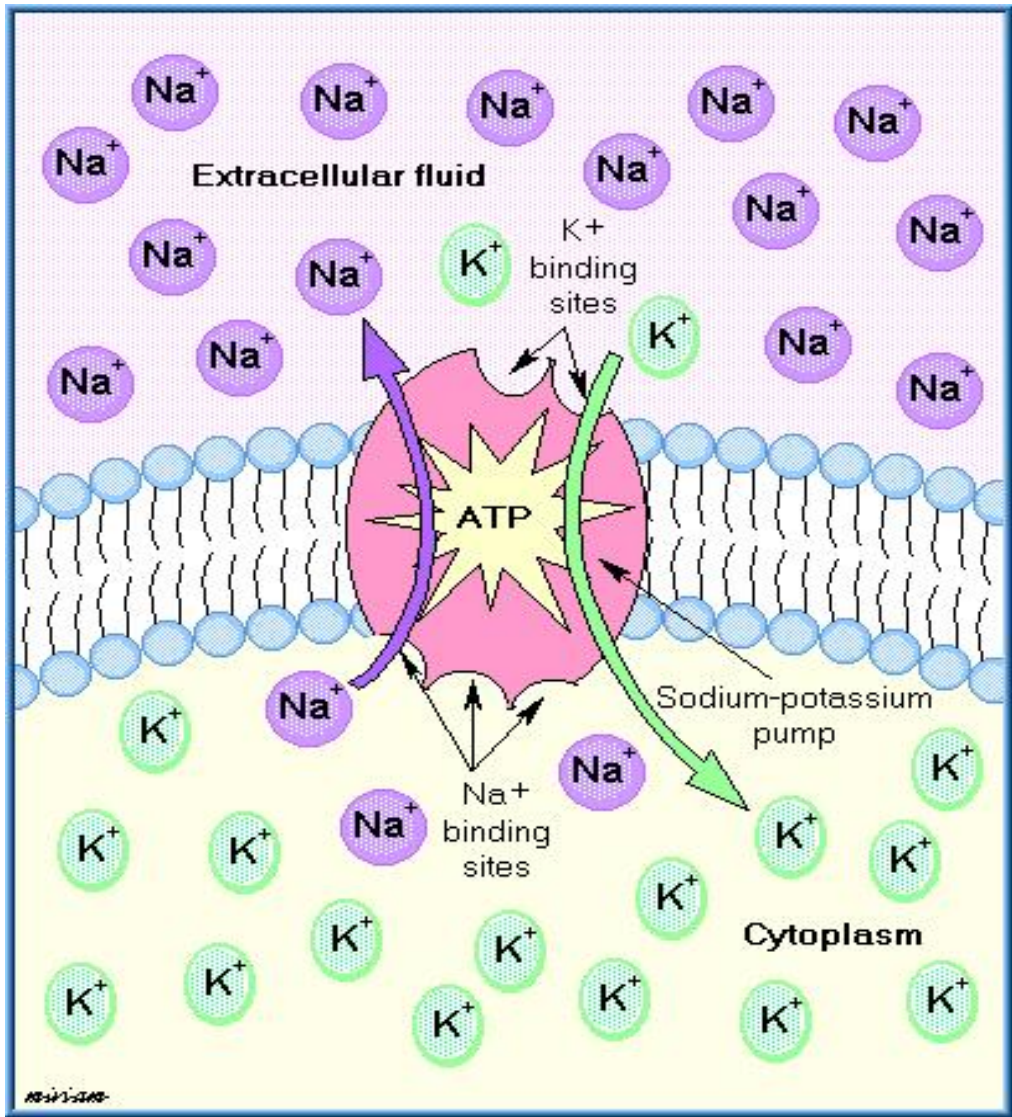
Antiport

- carries two or more solute in opposite directions (countertransport)



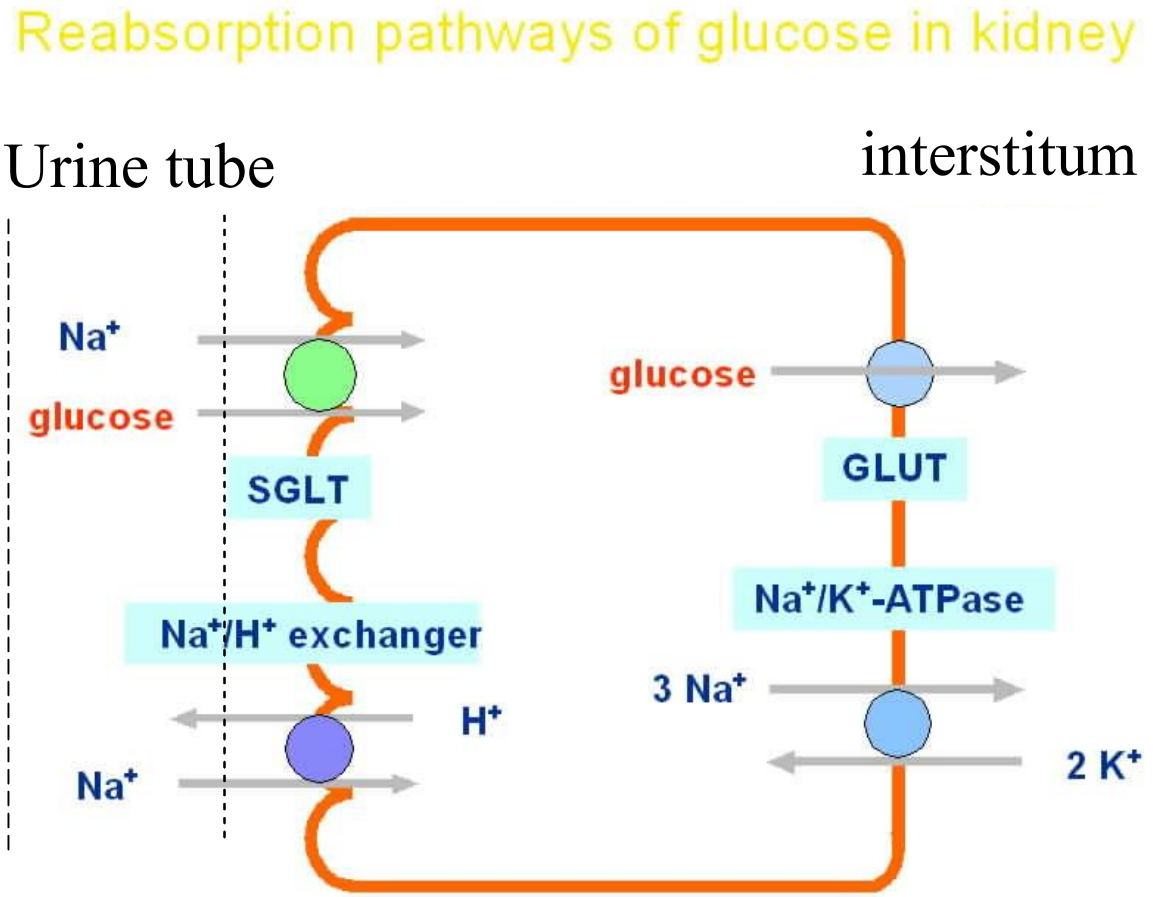
Sodium Potassium Pump

- Half of the bodies calories consumed each day are used by the Na/K pump
  - Regulation of cell volume
  - Heat production- when cold, thyroid hormone causes increased production of Na/K pumps
  - Maintenance of membrane potential



Sodium Glucose Transport Protein

- Used in the kidneys to salvage glucose from the urine.
- Na/K pump removes excess Na from cell

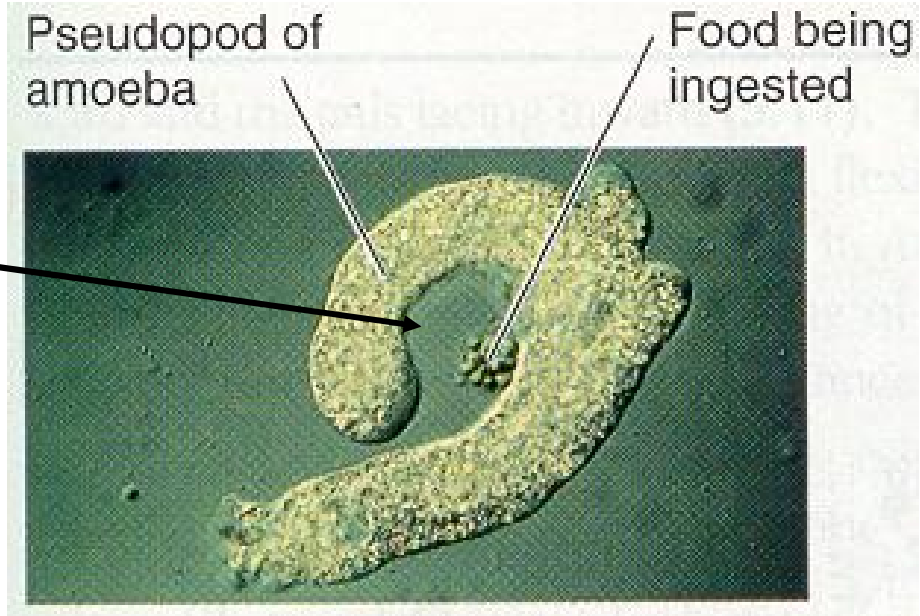


Active processes (cont)

- Endocytosis- process of bring things into the cell.
- Exocytosis- process of expelling things from the cell.

Active Process (cont.)

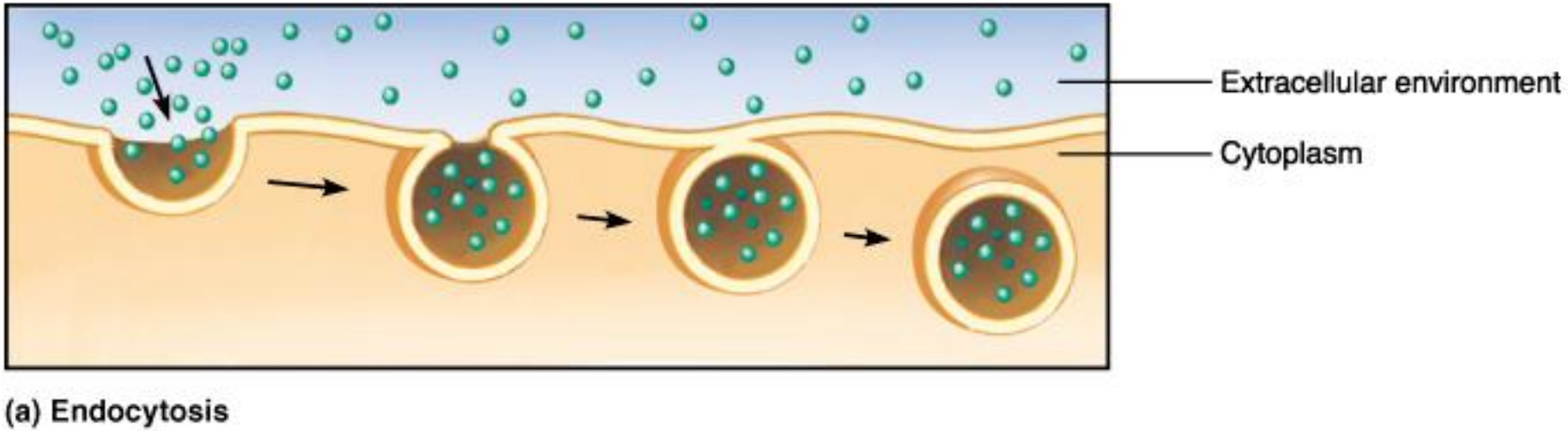
- Endocytosis- a portion of the cell membrane encloses the substance and brings it into the cell.
  - Phagocytosis (cell eating)- projections of the plasma membrane (psuedopods) surround a large particle and brings it into the cell.



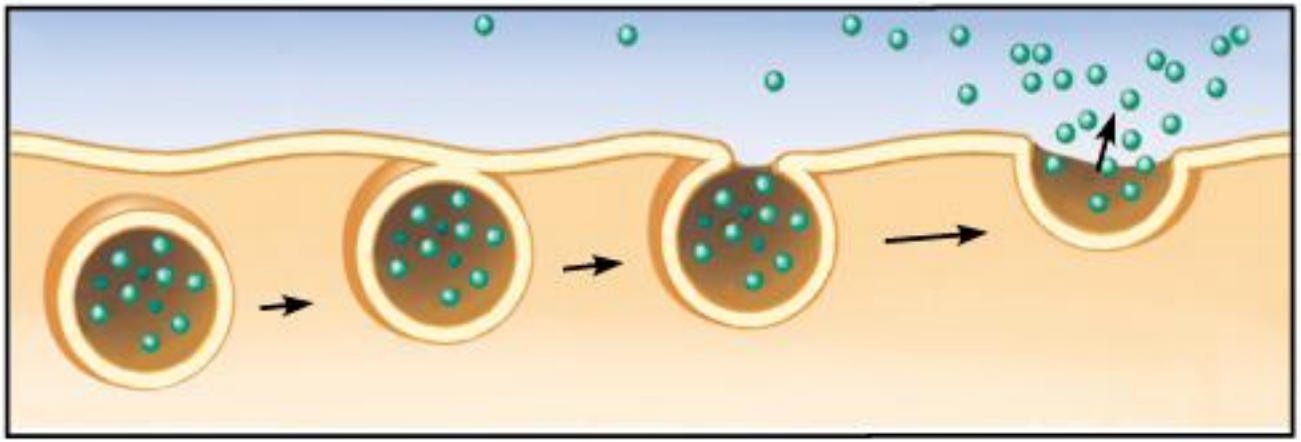
Benjamin
Cummings

Pinocytosis

(Cell Drinking)



(a) Endocytosis

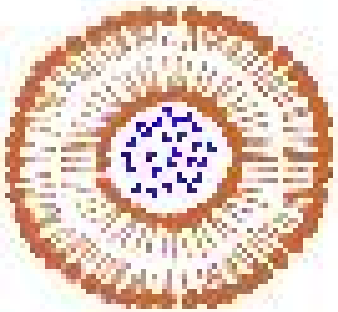


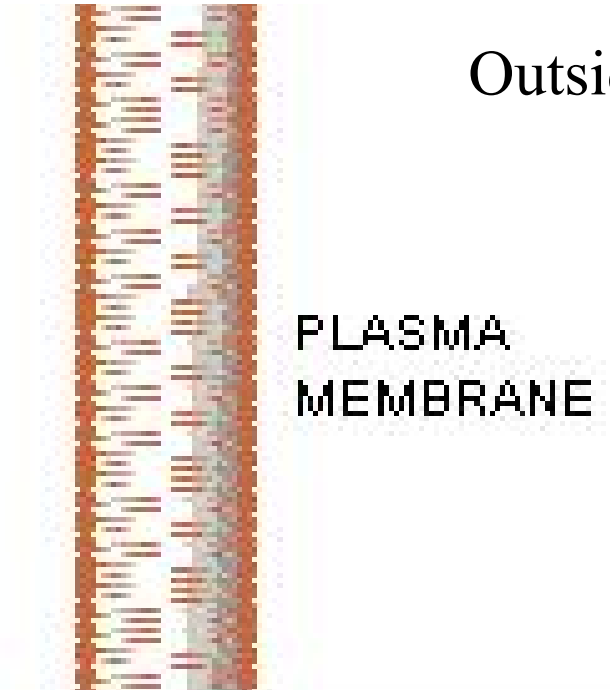
(b) Exocytosis

Copyright © 2001 Benjamin Cummings, an imprint of Addison Wesley Longman, Inc.

Exocytosis

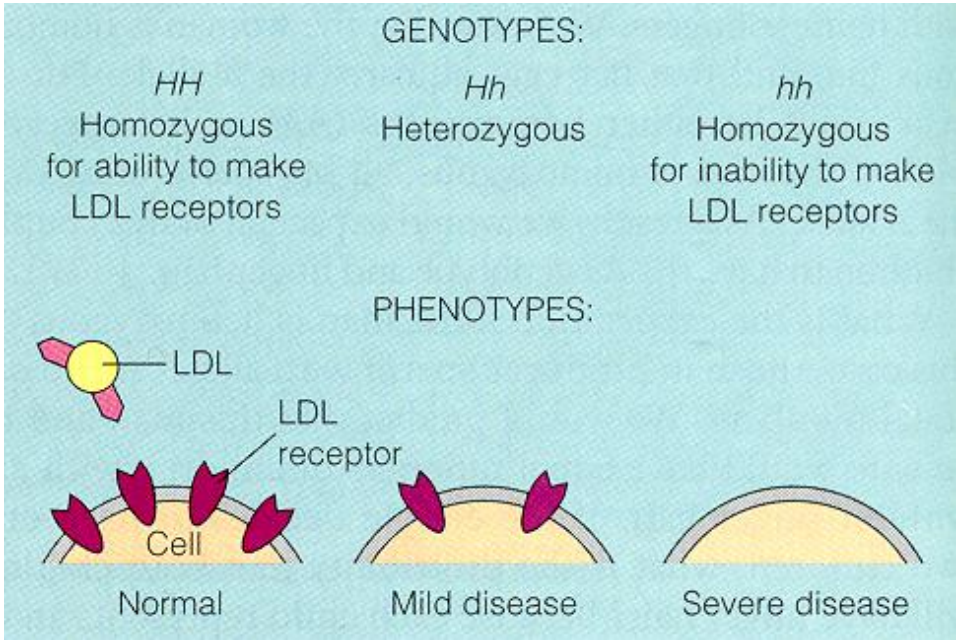
Inside cell

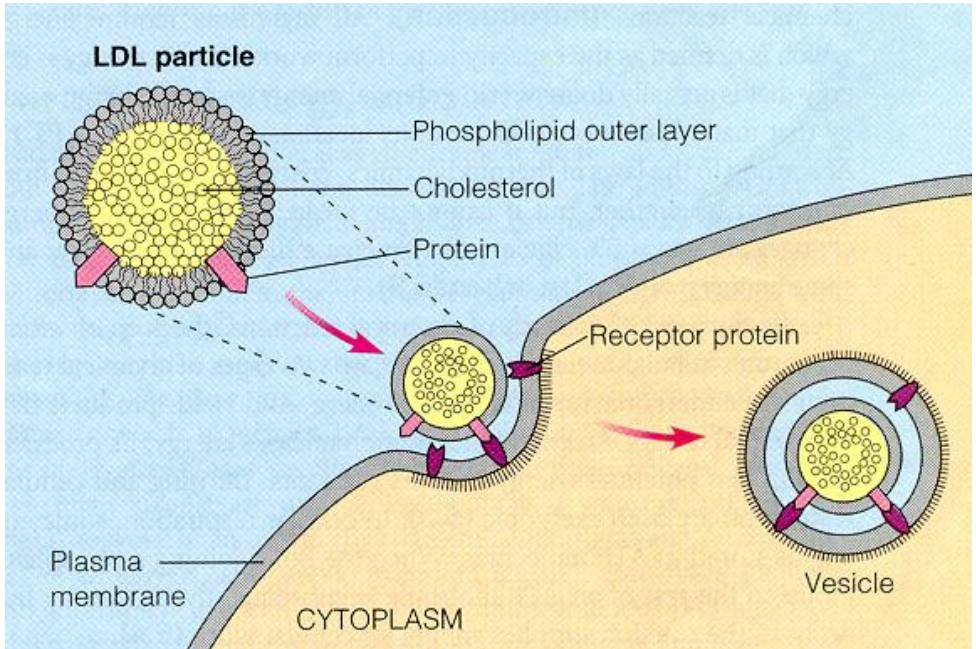




Outside cell

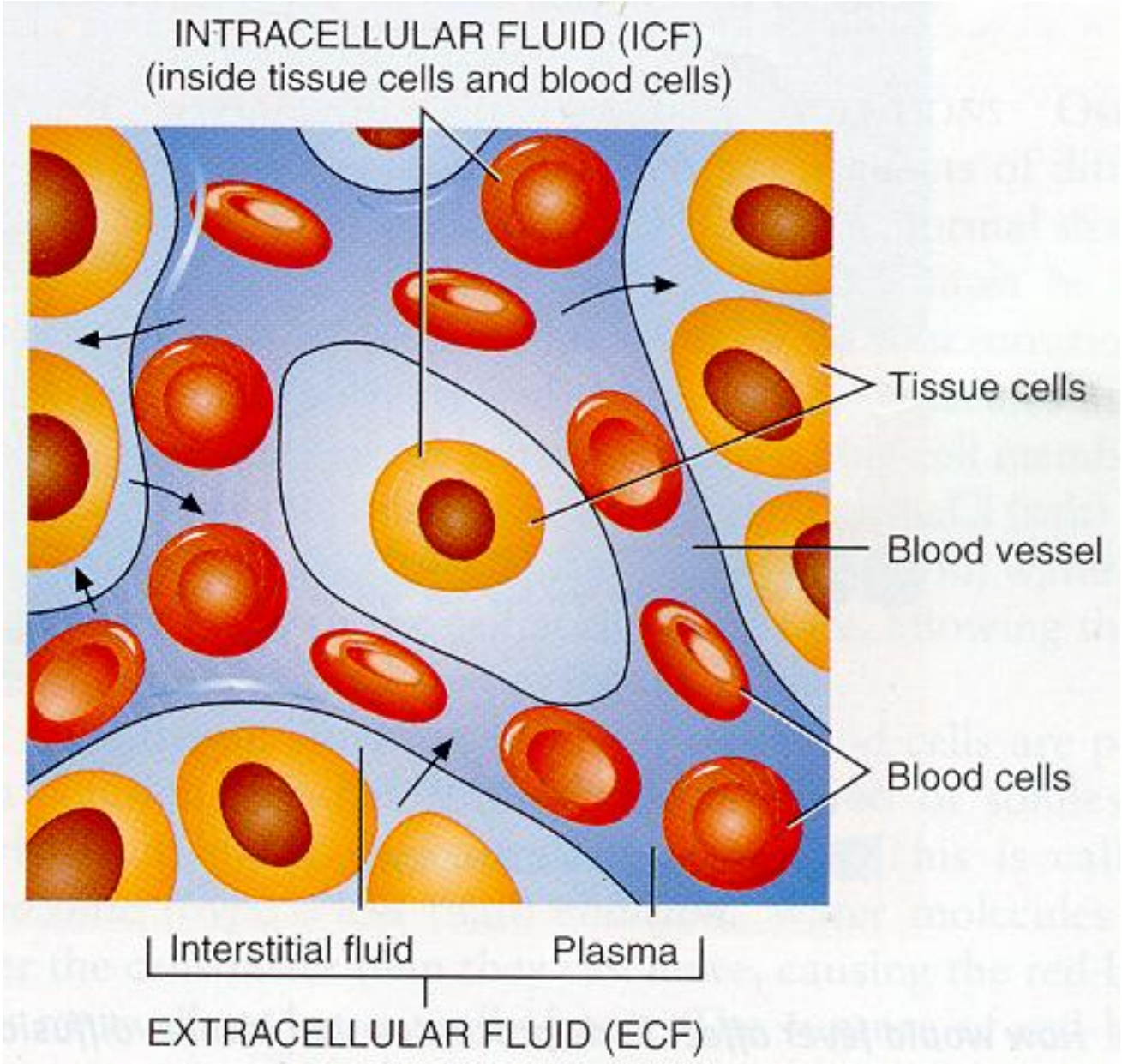
Receptor Mediated Endocytosis

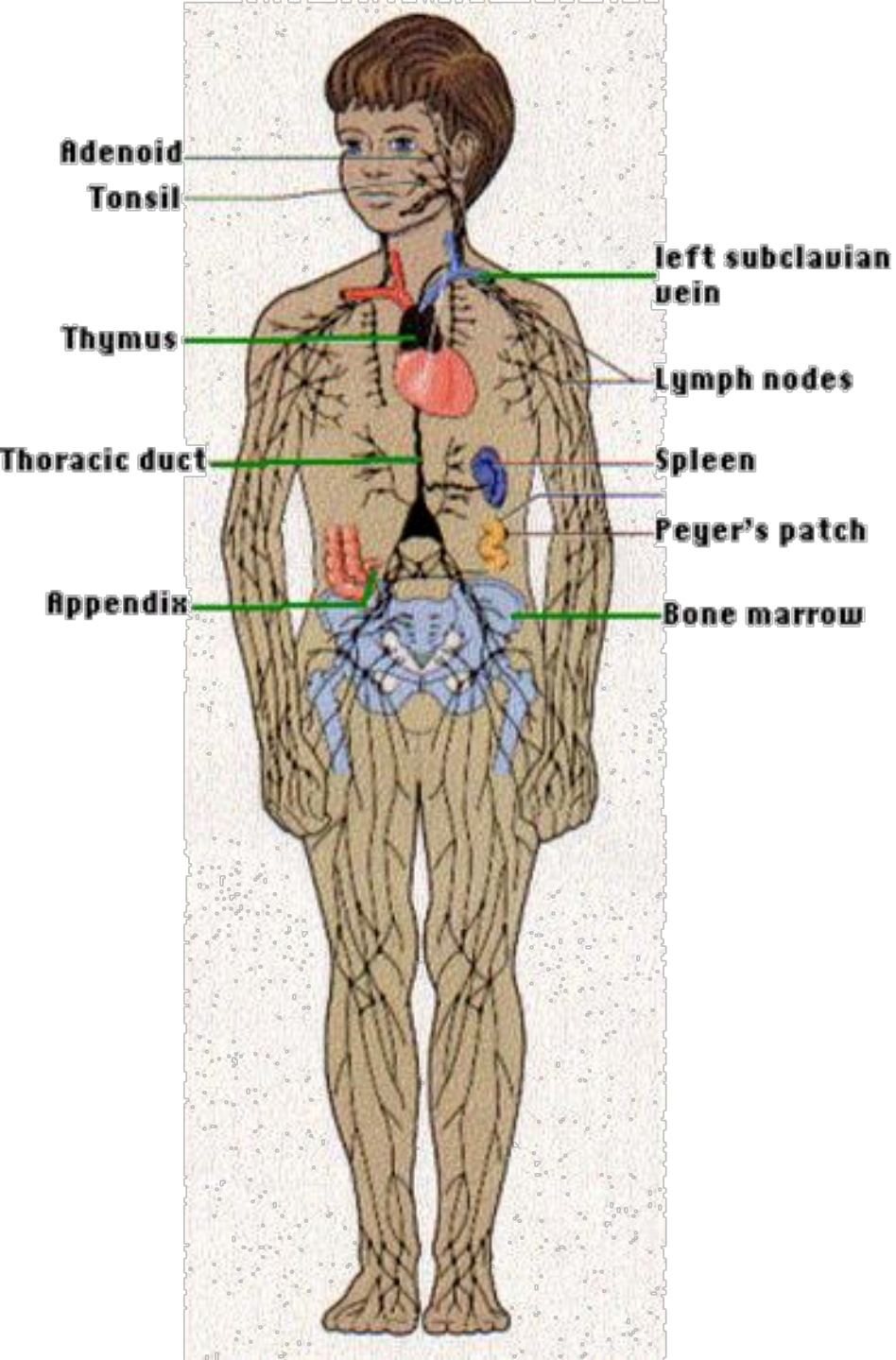




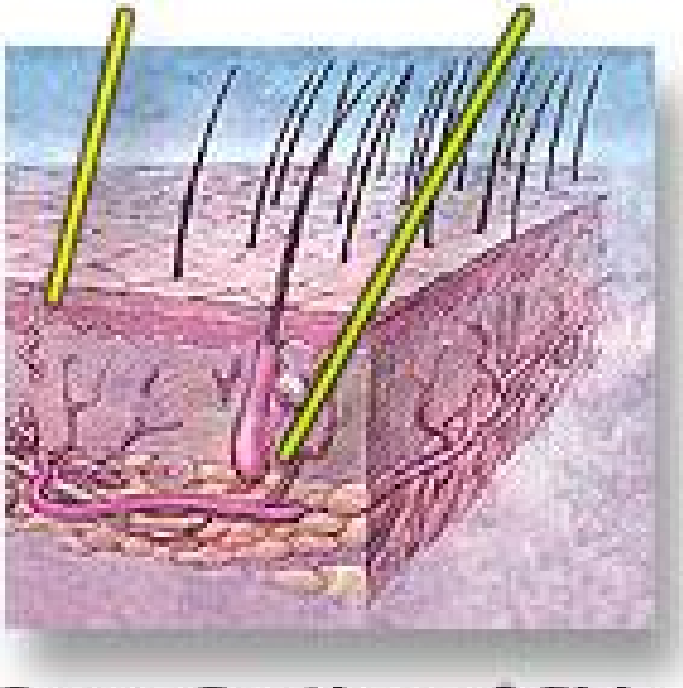
Cellular Environment

- Intracellular fluid (ICF, cytosol)- fluid inside the cells.
- Extracellular fluid (ECF) - fluid outside the cell
  - interstitial fluid- fills the spaces between the cells
  - plasma- fluid in blood vessels
  - lymph- fluid in lymphatic vessels

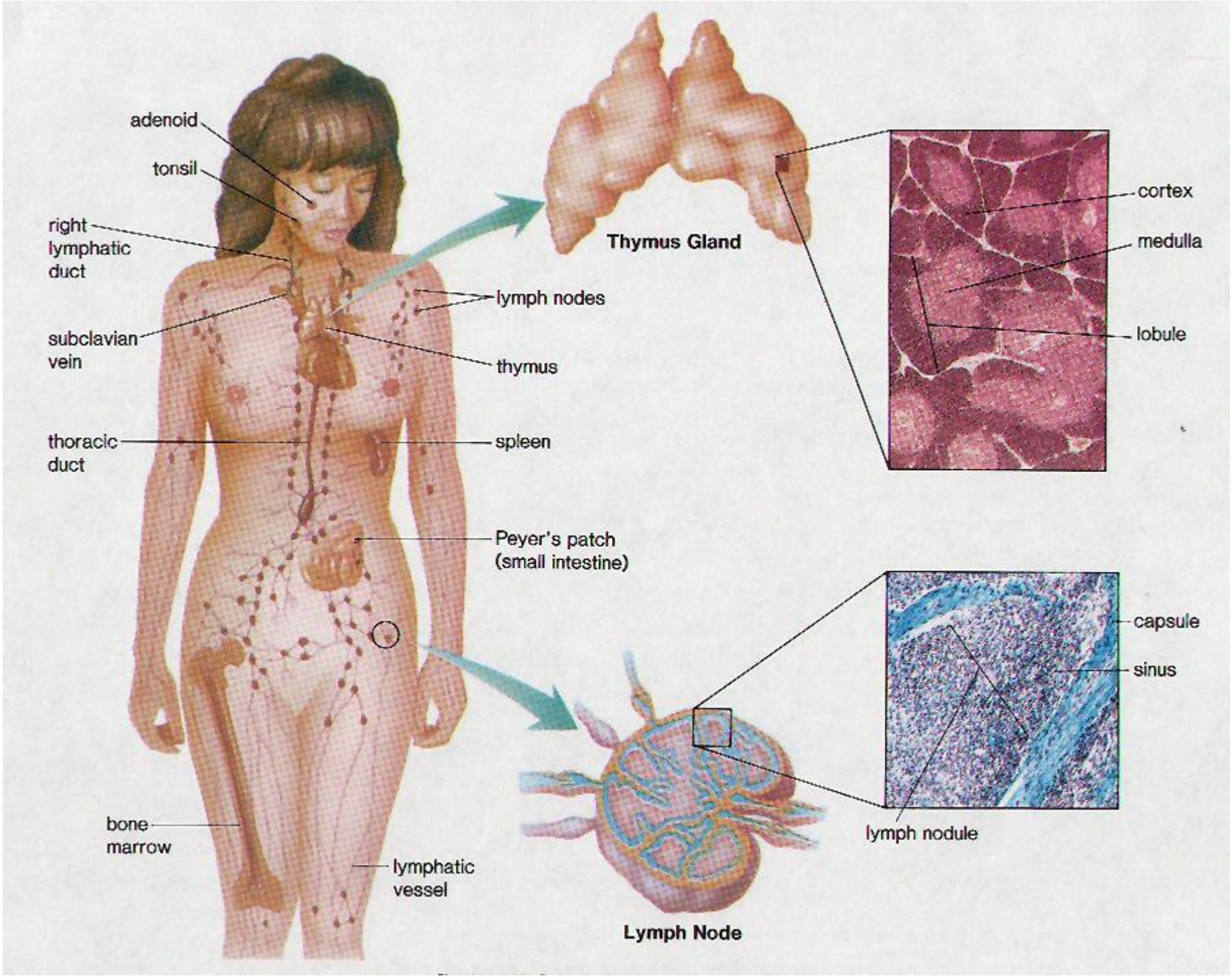

INTRACELLULAR FLUID (ICF)
(inside tissue cells and blood cells)
Tissue cells
Blood vessel
Blood cells
Interstitial fluid
Plasma
EXTRACELLULAR FLUID (ECF)

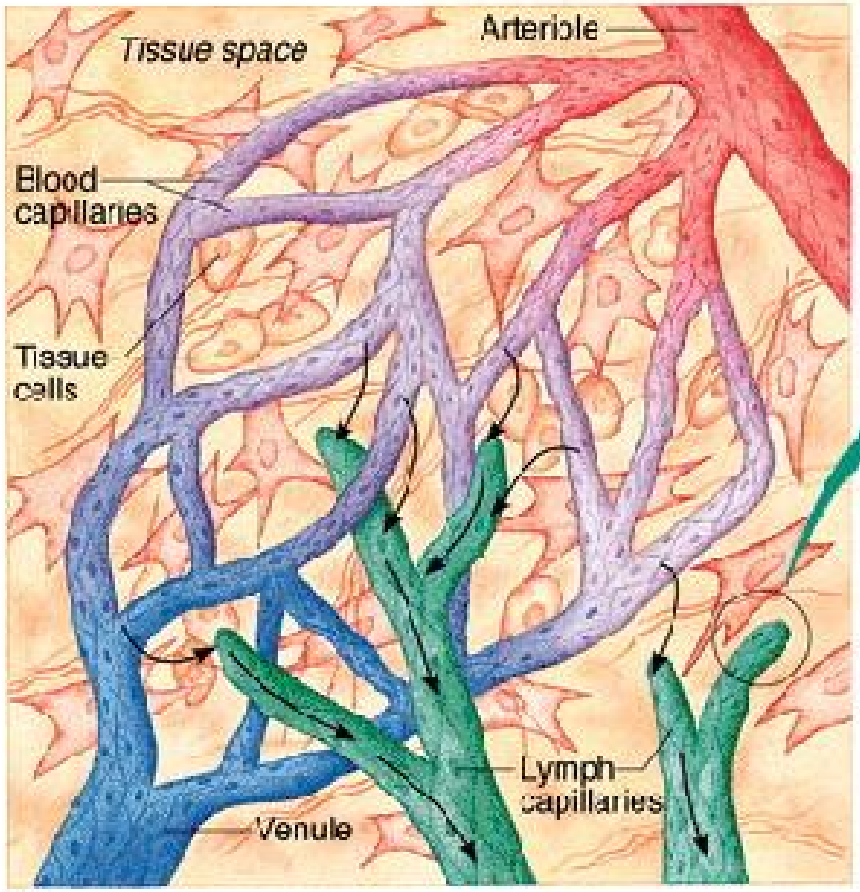


Cleansing Pathways

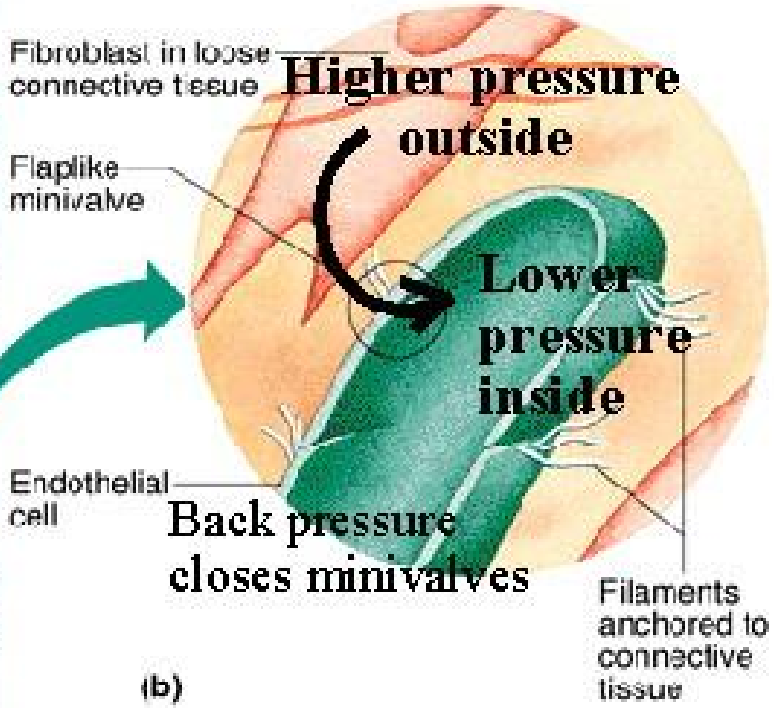


Cross Section of Skin


adenoid
tonsil
right lymphatic duct
subclavian vein
lymph nodes
thymus
thoracic duct
spleen
Peyer's patch (small intestine)
bone marrow
lymphatic vessel
Thymus Gland
cortex
medulla
lobule
capsule
sinus
lymph nodule
Lymph Node



(a)



(b)

Lymphokinetic Motion and Pressure Gradient

Blood capillaries → Interstitial Fluid → Lymph capillaries → Lymph veins → Lymph ducts → Large circ. Veins

Highest pressure

Lowest pressure